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DEPARTMENT OF DEFENSE

Training Guide

PRINCIPLES AND APPLICATIONS of VALUE ENGINEERING

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Prepared for the

OFFICE OF ASSISTANT SECRETARY OF DEFENSE

(Installations and Logistics)

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PRINCIPLES AND APPLICATIONS

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FOREWORD

The objectives of this Training Guide are ~~to~~ provide: a) a complete understanding of the fundamentals of the value engineering method, b) a familiarity with some of the ancillary material necessary to its performance, and (c) a description of value engineering programs. Some material on value engineering program management is provided, such as contractual aspects, organization and assessment of results. The subject matter is presented in generic form. ~~Each user will be able to make specific applications to his agency with its unique~~ considerations.

It is intended that this Training Guide will be used in conjunction with a formal course of the same title. The course will be suitable for those who will perform value engineering as an assigned responsibility and for personnel who need to know how to apply it in their daily activities. The class work will encompass lectures and practical project exercises. The project work provides an opportunity to apply the theory under an instructor's guidance. Upon satisfactory completion of the course the trainee will be qualified to perform value engineering studies. With minimum supervision, he should be able to implement a value engineering program.

There are no formal educational prerequisites for a course based on this Guide. It would be helpful, however, to have an understanding of the DoD procurement practices, costing and pricing. Elementary algebra is used in the discussion of cost models and cost analysis.

An examination has been prepared based upon the text. It is issued as a separate supplement to this Guide. Satisfactory completion of a

value engineering course is predicated upon a passing grade in the examination and active participation in the project work exercises.

It has been found that a student's mental attitude toward learning has a significant bearing upon the amount of material he absorbs and retains. This Guide will be used by many who have been away from a formal educational environment for some time. The state of mind which exists during schooling is subject to change by work experiences. To gain the maximum benefit from this material, it would help to consciously adopt the student's posture of receptiveness to learning. The prime purpose here is to learn; this will facilitate later adaptation of the subject matter in individual circumstances.

CONTENTS

ILLUSTRATIONS

Chapter 1: Fundamentals

This Chapter defines some of the basic nomenclature to be used...the subject of value is discussed in detail...a basis is provided for the consideration of end item value for DoD application...the defense industry environment is briefly examined as it relates to value engineering... Guidelines are presented for setting boundaries for the scope of value engineering activities...its methods of application...and the selection of subjects for value engineering studies.

CHAPTER 1

FUNDAMENTALS

TERMS AND DEFINITIONS

There is at present a number of definitions of value engineering in existence. The growth of a discipline involves the participation of many people in widespread areas. The pace of technical progress in growth situations frequently does not permit sufficient communication between the participants to develop standards.

This Guide will express the value engineering nomenclature by considering three of its aspects. First, the theoretical or disciplinary aspects; second, the value engineering program; and third, the personnel who are engaged in value engineering. None of the definitions provided in this document are dogma; none are intended to represent the only definition, or even the best definition that could ever be made.

Value Engineering Discipline.

The value engineering discipline is an analytical process of identifying needed functions and establishing the minimum cost to provide those functions in order to maximize end item value. Broadly stated, it is the theory of the method. It is a discipline that is cost-reduction oriented. By definition it is an analytical process; it involves probing and evaluating in order to improve understanding. The words "needed functions" convey the meaning that value engineering is concerned with what is to be done and the reality of the need for doing it. For example, the value engineering theory seeks minimum cost by considering various methods of achieving the function rather than by considering ways of reducing cost of a specific method which leave it substantially unchanged.

Value Engineering Program.

A value engineering program is an organized set of definite tasks which support or apply the value engineering discipline in all elements of an organization that affect cost. The word "organized" is significant. Unless planning, scheduling, measurement and other control procedures are applied, one does not have a value engineering program, or any program. "Definite tasks" indicate that the program elements must be stated (and understood) in sufficient detail to be logical entities which can be assigned, manloaded, costed and assessed. The phrase "in all elements of an organization" indicates that the existence of a value engineering effort in an isolated section of an installation would be unlikely to qualify as a value engineering program.

Value Engineering Personnel.

These are designated individuals who have been trained in the value engineering discipline and who have responsibility for its application. These personnel should have "Value Engineering" in their job description, classification, title, or whatever is appropriate in their organization. Specialty value training should be in the person's background. The definition also states that to qualify as value engineering personnel, one should have responsibility for application. The most desirable form for this responsibility is as a full-time effort.

Value.

There is greater common understanding of the word engineering than there is of the word value. The dictionary has several definitions of value. The ones that best fit the value engineering situation are: "relative worth, utility, or importance; degree of excellence; a numerical quantity assigned or computed." Value in this usage is measured in the eyes of the beholder. It is a relative and subjective item. Firm and definite rules for its measurement are not available. It must be borne in mind in relation to item value, current applications or needs.

Use Value. The economies discipline has subdivided value into many types. These include the value an object may possess because of its ability to do something. This is referred to as its use value. It represents the properties and qualities which accomplish work or service. Use value

includes all of the performance requirements which are necessary for the item to perform its intended application at the needed time.

Esteem Value. This represents the properties, features, or attractiveness which create a desire to be known to possess the article. An item may have little or no use value and yet have a significant esteem value. For instance, real jewelry might be used in a play instead of costume jewelry. The costume jewelry could perform the same use, but it would not have the same esteem value to the actress.

Aesthetic Value. Esteem is different than the value ascribed to an item simply because it is beautiful. The worth of appearance is called aesthetic value.

Exchange Value. Another value which can be recognized is exchange value. It measures the properties or qualities which will remain attractive enough to other people to permit re-sale in the future. Exchange value is demonstrated by the trade-in book value of automobiles.

Cost Value. The cost value of an article represents the summation of the various costs required to produce it. It can be measured by the seller and expressed in dollars.

Price and Value. The formerly elusive parameter, value, can now be qualitatively approached. It can be treated quantitatively if in addition to identifying the values offered by an item, an equivalent dollar amount is assigned to each value. The sum of the dollar worths of the values offered by an article must be equal to or less than the price of the article (viz., cost value) for the purchaser to say, "That is a fair price." Buyer and seller may disagree on the worth of the values present in any article.

The value engineering approach to DoD items is that the use value should equal or exceed the cost value. Esteem, aesthetics and exchange values are negligible compared to use. The value of an end item approaches its maximum if its cost is made up solely of features which contribute to its use and do not include any factors which contribute cost towards esteem, aesthetics, or exchange. A value engineering goal is the maximization of end item value through the control of use value and cost value and the elimination of costs associated with any other value.

Function.

As noted previously, the value engineering discipline deals with the functions of items. Function is used here to mean the action for which a thing is specially fitted, or used, or for which it exists. The value engineering approach is to be concerned first with what the item is supposed to do--only afterwards with the item itself. For example, before considering a fabrication method improvement for a certain part, the realism of the need for the function should be satisfied, and then other ways of performing the item's function should be investigated. The consideration of function is the fundamental skeletal structure of the value engineering method, for all applications by all users.

Value Analysis, Value Control and Value Management.

The DoD makes no distinction between the terms value analysis and value engineering. Furthermore, the DoD contractually speaks of value engineering. Value Control and Value Management are terms used by some companies to describe their value programs. This Training Guide will use the term value engineering and it may be considered synonymous with the others mentioned above.

Value Assurance.

The term value assurance will be used in this Guide to indicate the application of value engineering during the initial creative phases of an item; for example, during hardware design or procedure preparation. Its efforts are intended to assure a high value item when released for fabrication or when placed in service. It has its parallels in reliability assurance and quality assurance.

Value Improvement.

Value improvement will be used in this Guide to refer to the efforts applied to an already existing serviceable article to recreate one of better value. Broadly stated, it is an after-the-fact approach.

ENVIRONMENT

Value engineering is a commercial industry development of the mid-1940's. It was called value analysis at that time and was applied mostly to high volume hardware items after their design was completed and

sometimes even after production had started. Its purpose was primarily to increase profit. The incisiveness of the theory was recognized and adopted by elements of the DoD in the early 1950's. Since then it has been promulgated throughout the defense industry, the DoD and other Government agencies.

Department of Defense Usage.

Early applications of value engineering within the DoD resulted in higher value items, but occasionally the implementation costs prohibited using the results. Changes to defense inventory items approved for service may entail expenses for changes to manuals, re-procurement of new spare parts, stocks of two kinds of spare parts and updating records and data. This fostered the development of value engineering techniques that would be applicable to the R & D phase of acquisition. The use of these methods prior to production avoids unnecessary initial expenditures. The DoD environment today provides opportunities for the application of value engineering to many existing items and the capability to assure value during the early acquisition phases.

Cost Reduction Pressures.

It is not realistic to say that value engineering, per se, should not be necessary and, therefore, contractors should not receive any benefits for doing it. The extensive use of cost-plus-fixed-fee (CPFF) contracts in defense procurement did not provide strong incentive for economy. The incentive did not exist for the individual personnel in industry to reduce costs. Many of the CPFF procurements were for research and development. This involved a high percentage of the nation's engineering and support personnel. Therefore, many personnel associated with defense inventory items today have background experiences gained in an environment that was not positively oriented towards cost conservation.

Personal Factors.

Cost incentive contracts are now prevalent and an individual's cost performance influences his company's final profit. The DoD has responsibility for spending public funds. Each installation and its personnel are under scrutiny for its cost effectiveness performance, as well as its functional performance. Companies and military agencies have intensified the

monitoring of individual cost effectiveness performance. Military directives have been issued which state that cost effectiveness performance is a factor to be considered in preparing personnel rating reports.

DoD Cost Reduction Program.

The Department of Defense has increased the pace of the cost reduction program announced in 1962. President Johnson and Secretary of Defense McNamara have directed the attention of all major industrial defense contractors to this cost reduction effort.

Value engineering is one element of the DoD cost reduction program. The DoD has created a top level Value Engineering Council of service and agency representatives to develop coordinated procedures and policies. The Directorate of Productivity and Value Engineering and the Value Engineering Services Office have been established in the office of the Deputy Assistant Secretary of Defense (Equipment Maintenance and Readiness).

APPLICATION

End Items.

The daily operation of value engineering is concerned mostly with assemblies and detail parts and their data rather than with entire systems. Its concern is during their conception, development, prototype fabrication, production, installation and operation. The scope includes the nonhardware cost contributing elements of data and documentation associated with the hardware end items. Some non-hardware examples are: a) the preparation of technical manuals, b) establishment of requirements for data, c) report preparation, and d) preparation of engineering drawings. It can also find application in the facilities or architectual and engineering (A & E) field. The principles are applicable but it must be during the early stages before the "mortar" has set. Maintenance of military equipment offers many opportunities for the application of the value engineering method.

Value engineering operates mostly on the personal level with those decisions which an individual finds under his sole control. It does not usually include decisions, such as whether a nuclear-powered aircraft constantly aloft provides a more cost effective deterrent than a Polaris submarine on station.

Timing.

The use of value engineering must consider the point of application in the life cycle of the material involved. There are various acquisition cost factors which constrain the practicality of value engineering application. Generally, as a design matures and its configuration firms, the accomplishment of value engineering cost reductions becomes more difficult and more expensive. There is a point in the acquisition cycle at which an ostensible reduction in acquisition (or procurement) cost might mean an overall cost (acquisition plus installation, operation and logistics costs) increase. Value engineering in early design and development phases can achieve maximum cost avoidance because variations can be implemented without offsetting production and logistics change costs.

Defense inventory items are frequently re-procured over a span of several years. This provides an opportunity for taking another look. Some of these opportunities are offered by the re-procurement of items that satisfy their requirements even though they may not be doing it for the best value. Also, the passage of time permits taking advantage of commercial processes that were laboratory curiosities when the initial procurement was made.

Type.

In addition to selecting the appropriate subject and establishing the point in time that is suitable, the type of application must be determined. The Armed Services Procurement Regulation (ASPR) permits two types of contractual application of value engineering in industry contracts. The contractor may be paid a direct sum of money and is required to develop and implement a value engineering program on a particular contract. Or, is not required to do anything, but, if he does perform successfully, he will be given a share of the resultant cost reductions. Application within the DoD requires selecting the proper program tasks as discussed in Chapter 4.

Results.

The results of value engineering efforts are both direct and indirect. The objective of value engineering is the improvement of value which may

be (and usually is) obtained by the reduction of cost. Direct results are the achieved cost reductions which can be unambiguously measured.

However, a significant portion of value engineering achievements are gained through the efforts of personnel other than designated value engineering personnel. Their results are not always clearly visible nor immediately evident. This is not to say that they are not real. The development of value engineering and the resultant application to the early design phase have produced results which are more easily and realistically measured in units other than dollars. There is, for example, an improvement in a company or military office cost-consciousness atmosphere. This is a highly desired result, since the lack of this atmosphere is an environmental factor that has contributed to the need for the subject. Indirect benefits also result from increasing the capability of personnel to produce a more cost-effective product than they might otherwise do.

Direct results frequently occur in other than cost units: a) improvements in reliability, b) improvements in ease of supply, and c) increases in the opportunity for competitive procurement. These other factors, although real, tend to be subordinated to claims of savings.

PROJECT SELECTION

Project selection deals with choosing items for specific value study. It is a different situation than the application of value engineering principles in daily routine. Project selection seeks to identify and isolate items for intensive value engineering application. The question can be asked: "How is one to know that an item can be value-engineered?"

Identification of Values.

The process for selecting hardware and software projects suitable for value engineering involves the application of certain criteria in order to assess the item's rating as good value or poor value. The answer lies in the identification of the values which it possesses in terms of use, esteem, etc., and the cost contribution for each of these values. A broad functional cost and worth evaluation will provide a measure of confirmation of value status. The details of functional analysis are presented in Chapter 2.

Probability of Implementation.

Another parameter that should be involved in the selection of projects is the probability of successfully incorporating changes. Certain factors need to be considered here which may vary between projects and programs. One of these is the state-of-the-art that a particular item represents. The likelihood of improving items which have been subjected to many cost reduction studies during a long life certainly is less than that of newly developed items which have probably not been studied for their value engineering aspects. The local atmosphere about changes is a factor that will affect the success probability. Another factor that can be involved is the level of technical knowledge concerning the project which is available to the persons performing the study.

Schedule.

The effect upon the article's schedule should be considered. At the hardware level of value engineering application it is seldom justifiable to sacrifice schedule for cost reduction. Some past experiences have indicated that value engineering application may improve procurement lead times. In any event, major potential cost reduction trades should be examined to see if schedule changes might be justified.

Total Potential Cost Reduction.

The total cost consequences of a particular study must be evaluated before the study is to be made. This includes a rough order of magnitude estimate of the likely possible cost reduction that is achievable in terms of the production quantity and the present cost of the item. The likely implementation costs must be estimated by rules of thumb and experience factors. This will help decide if a particular project offers enough potential to make it worth the study. An item of high unit cost may offer less potential than an item of lower cost which will be used in larger quantity.

Worth of Study.

The length of time (hence, the cost) required for study, investigation, and action to arrive at the point of change may negate the overall reduction of its cost. Additionally, each time an item is value engineered and revalue engineered, the actual dollar cost reduction diminishes. Expressed

as a percentage, it may remain constant or even increase. In all cases, it should be assured the return is worth the investment.

Other Aids.

The total combination of its representation as good or poor value, the probability of successful improvement, the effect upon schedule, and the cost consequences provide a logical picture of whether a project is fertile or not. The performance of these tests is a matter of the skill and experience of the personnel involved in them. There are aids for determining these parameters. If a PERT or PERT/COST system is in use on a program, it will help provide the cost and schedule consequences of variations in program timing resulting from value study of a particular project. Learning curves are helpful for evaluating changes in production. Some of the cost analysis techniques in Chapter 3 may be applied. Cost target systems discussed in Chapter 4 identify items during their development that are candidates for value study. Computers can be a valuable tool to identify items for study. Computers already in use at many DoD procurement, supply and maintenance activities can be programmed to provide a print out when an item is in a "buy" position in sufficient time to permit study prior to reprocurement.

FUNDAMENTALS: SUMMARY

A. The value engineering discipline is an analytical process of dealing with needed performance functions to achieve best value by providing these functions at minimum cost.

B. A value engineering program consists of an organized set of tasks which support and apply the value engineering discipline in the elements of the organization that influence end item cost.

C. The values present in an item may be identified, measured and used as an indication of price reasonableness.

D. The value engineering approach for defense inventory items is to obtain use value at minimum cost and to eliminate factors which contribute cost to aesthetics, esteem, or exchange.

E. Cost effectiveness is an element of individual performance that is gaining assessment attention.

F. The scope of value engineering application includes hardware and non-hardware items of the entire DoD inventory at all stages of their acquisition and usage that offer cost reduction potential.

G. The selection of an item for value engineering study depends upon its value rating, probability of successful improvement and the anticipated return on the cost of study.

H. The results of value engineering include direct cost reductions achieved by actions applied directly to specific items and indirect benefits which accrue from the establishment of a value climate and the improvement of personnel cost reduction capabilities.

Chapter 2: Methods and Procedures

Analysis of function, the Job Plan and creative problem solving are offered as three basic elements of value engineering... analysis of function is presented as the value engineering method of achieving cost effectiveness in personal decisions... functions are defined and typed... the comparison of worth of function to the cost of achieving function is explained... The Job Plan is introduced as a set of tasks for performance of a value engineering study... the separate steps, or phases, of the Job Plan are defined... the work content of each is explained... and the personnel responsibilities are identified... Creative and analytical problems are defined... the significance of the creative problem in value engineering application is noted... some personal capabilities which can improve the generation of solutions are interpreted... definite methods are provided to increase the probability of finding the best solution to a creative problem.

CHAPTER 2

METHODS AND PROCEDURES

ANALYSIS OF FUNCTION

The fundamental element of the value engineering discipline is the analysis of function. It is the means of relating use value to performance with positive consideration of cost.

Description.

The functions of hardware and software may be analyzed at any stage of their existence. When applied in the conceptual stages it deals with the requirements for which a hardware item or document is being sought. The term "item" is used in this Guide to denote both situations. The functional analysis procedure involves the treatment of three facets of the item under study, together with possible alternatives or solutions: a) function, b) worth, and c) cost. Each parameter is determined, evaluated and compared. Subjective impressions are used in the process; judgment must be exercised. Functional analysis as discussed here bears some similarity to systems engineering as applied to weapon system analysis.

Function.

Functions can be expressed, categorized and handled just as any other descriptive element of an article, such as its weight, length, or color. There are several good definitions in current use for this term. For this Guide, functions may be thought of as the features that an item possesses, or that constitute its performance. They are traits of tangible hardware parts as well as of documents and procedures.

Function Format.

Functions are expressed as two-word abridgements of the performance features involved. The use of only two words, a noun and a verb, assists in achieving a high degree of summarization of the performance feature. It forces an exact statement of the problem, which in turn helps provide a broad opportunity for solution.

Thus the common screwdriver would be said to "transfer torque" rather than to "drive screws." True, it can be (and is normally) used to insert or to remove screws. But the common screwdriver would not work if it did not transfer the twist of the wrist to the screw head. It is that transfer that must be attained. If the handle of the screwdriver slips around the blade tang, no force is transferred, the screw doesn't come out, and the function is not performed.

Basic Function. Functions can be divided into two types, which are here labeled basic and secondary. Basic function is defined here as the performance feature that must be attained. In the case of the screwdriver, transfer torque would normally be the basic function. If the major performance feature was something other than associated with the driving of screws, the basic function might be something else. For example, if the desired application were the prying open of paint can lids, the function would be in terms of the transfer of a linear force rather than a rotational force.

The establishment of basic function is relative to the requirement. A clear understanding of the real need for the requirement is necessary if clarity of basic function definition is to be obtained. An item may possess more than one basic function. This would occur where one item provides several performance features that need to be accomplished.

Secondary Function. Secondary functions are also performance features of an item other than those that must be accomplished. Secondary functions represent those features whose existence is necessary to the performance of the item but are attributed to the method chosen to perform the basic function.

Thus a screwdriver may also be said to "insulate energy" if it has a plastic or rubber handle. This would be a secondary function if the handle

material was chosen to increase the friction between hand and handle, that is, to facilitate performance of the basic function.

The handle itself, regardless of its composition, may represent a secondary function in another situation. Viewed from the requirements side, the basic need is to drive screws. If a hand-operated screwdriver is chosen to perform this basic function, the handle function is secondary. It exists only because the device called a screwdriver was chosen to perform the basic task. If a coin, or a thin flat blade, like a spatula blade, were chosen, there would be no handle. The screwdriver handle provides a support feature necessary for it to perform the basic feature of driving screws when held in the hand and twisted.

Functional Relationships. It is common practice in dealing with hardware to describe them as: a) elements of next larger assemblages, b) in terms of their own smaller subparts, c) or as an alternate to b) as non-divisible without losing their identity. The relative position that an item occupies in the scheme of total assembly is called its indenture. Indenture levels below the "top" assembly are developed and assigned as design proceeds.

The significance of indenture to this subject is that the designation of functions as basic or secondary depends upon the indenture level of the antecedent item. A function which exists to support the method of performing the basic function is a secondary function. But, when considered by itself with respect to itself, it is a basic function.

For example, the surface of the screwdriver handle that increases friction is secondary with respect to the screwdriver as a hand rotated device. But, if the surface of the handle is considered with respect to the handle, increased friction is the main performance feature that must be attained. Therefore, it is a basic function of the handle as a first indenture level item.

Application to Assemblies of Parts.

Some hardware items that appear simple have many levels of lower indenture. The rule for functional evaluation is to work from the top down and to consider the project under study as the top assembly. Perform the analysis of function upon the top assembly first. Only after assurance that

the objectives of value engineering cannot be achieved at the top assembly level should the first indenture parts be studied, and so on, down to the lowest level indenture.

For example, if the screwdriver were under value improvement study, attemps to improve the handle would be subordinated until it was determined that: a) performance of the function was needed for the application in question, and b) a manually rotated, spade-bladed device was the best approach.

Conservation of Function. Functions may be used as rough measures of cost effectiveness. This rule of thumb will generally hold true, but must be applied with good judgment. The value of an item approaches maximum as unneeded functions are eliminated and as the number of secondary functions is reduced.

Worth.

The second step in functional analysis is to establish a dollar figure for each needed basic function. This is done after all functions have been identified and typed and unnecessary functions have been discarded. Worth is the cost estimated to be a reasonable price to perform the function. The estimate is made by the person or team performing the functional analysis.

Procedure. The quantitative aspect of worth is a subjective element in value engineering just as it is in any context. Consumer consideration of whether to repair an old washing machine or to buy a new one and the decision of whether to buy a new set of golf clubs at a very good price when the old set is still serviceable are examples of worth decisions which are frequently made. These are usually made or strongly influenced by a "what is it worth?" consideration. A point is reached in the deliberation of purchase decisions when one concludes, "Not at that price; but if it were this price, it would be worth it."

Unfortunately, most of us are more adept at doing this exercise for consumer goods than for defense items. But it can be done for both. Some of the questions that might be asked for setting the worth of functions are:

A. What is the cost of achieving this function:

1) if some other known item was used?
2) if it had been done on some prior program?
3) if it were being done in commercial industry?
4) if it is bought from a competitor?

B. What price would you pay if it was your own money that you were spending?

C. Is this a common function of ordinary accomplishment or rare and difficult to achieve?

D. What is the price of some item that will:

1) almost, (but not quite), perform the function?
2) perform the function plus several others?

All of the above factors are guides, but experience and judgment must also be applied to set the worth of function. The procedure needs further development to increase its accuracy. At this moment, however, it can be performed well enough to serve a useful prupose. It is probably the most difficult step in the entire value engineering process. It is also one of the most useful.

Application. The establishement of a dollar figure for the worth of each needed basic function is a major goal of the value study. It is one boundary of the value aspect of the overall problem. The selection of one of several alternatives or solutions to postulated requirements is facilitated by comparing the cost of each to the worth of the functions that need to be accomplished. It thus serves a threefold purpose: a) a test for value, b) an element of evaluating decisions for approval, and c) a factor for measuring the effectiveness of value engineering efforts.

Cost.

The consideration of cost is the third step in functional analysis. As mentioned above, the magnitude of cost as compared to worth is a measure of value. In this application, it is the cost of the method chosen to perform the function that is considered. Worth applies to function; cost applies to the physical method of achieving function.

Determination. Cost may be determined by one or more of several processes. The choice depends upon the item's design completion status and previous procurement. Records should be searched for historical cost

data pertinent to the items under consideration. The cost estimating, pricing or analysis organization can be requested to derive a predicted cost for items under development or alternatives. Vendors may be requested to make quotations. In any event, it is the future cost for the quantity in question that is to be used. Past actual costs must be adjusted to reflect the future. These facets are discussed in Chapter 3.

Application.

Functional analysis is performed as one of the early steps in the value engineering method. Its use is summarized in Table 2-1. The method and the output is the same for all applications: the use of the results varies according to the item under consideration.

THE JOB PLAN

The Job Plan is a series of tasks whose performance constitutes the accomplishment of a value engineering study. Each step entails one or more elements necessary to the satisfactory conclusion of a value engineering study.

Significance.

The Job Plan is a key component of the value engineering process. It has been found in practice that its formal use is instrumental in achieving best results from value engineering studies. Excessive informality with respect to economic considerations contributes to a poor value environment. Conversely, rigorous use of the Job Plan provides:

a) A vehicle to carry the study from inception to conclusion.

b) A convenient basis for maintaining a written record of the effort.

c) Assurance that consideration has been given to facets that may have been neglected in the creation of the original article.

d) A logical separation of the distinct portion of the study into units that can be planned, scheduled, manloaded and assessed.

Application.

The Job Plan is used in training for the project work exercises and in actual practice for value engineering studies. As presented in this Guide, the Job Plan pre-supposes selection of an item for study. Some

Table 2-1. Application of Value Engineering Functional Analysis

Activity	Apply To	To Find	Express As	Identify For Further Use
Project Selection	Specific item of hardware or software.	a) Need for improvement b) Value status	a) Function(s) needed b) Worth of function(s) c) Cost of item	Ratio of cost to worth
Value Improvement Studies	Project	Data for improvement action.	a) Function(s) needed b) Function(s) provided c) Worth of basic function(s) d) Cost of item	a) Unnecessary function(s) b) Cost/worth ratio for each basic function c) Number of secondary functions.
	Possible Alternatives	Data for selection decision.	a) Function(s) provided b) Cost of items	a) Cost/worth ratios b) Number of secondary functions.
	Selected Item	Support data for proposal recommendation	a) Function(s) provided b) Cost of item.	a) Improvement of the cost/worth ratio b) Function(s) discarded c) Variation in number of secondary functions.
Value Assurance Activities	Problem to be solved or requirement that is to be met.	Data to assist in selection of solution.	a) Function(s) required b) Function(s) needed c) Worth of function(s)	a) Unnecessary function(s) b) Worth
	Possible Alternative Solutions	Data for selection decision	a) Function(s) provided b) Cost of solutions	a) Cost/worth ratios b) Number of secondary functions.
	Selected Item or Solution	Support data for decision approval.	a) Function(s) provided b) Cost of item	a) Cost/worth ratio b) Function(s) discarded c) Number of secondary functions

expositions include this in the Job Plan. The project must be selected in any case; the exclusion of project selection permits easier application during training.

As presently structured, the Job Plan is oriented towards value improvement studies. Its method and much of its content are also applicable to value assurance. A strong similarity exists between the Job Plan and the general process that is usually followed during hardware design, test procedure preparation and other activities of daily performance.

Personnel.

The Job Plan is used whether the study is being done by a group or by an individual. Each member of a tem need not separately perform the entire Job Plan. Individual assignments of some tasks may be made; these areas will be noted as discussed below and presented in more detail in the section on Task Forces in Chapter 4.

Records.

A written record should be maintained of the actions performed and the data that is gathered. When a Task Force is in operation each person who performs a separate assignment should provide the others with a summary of his results. The value engineering member of a Task Force usually serves as its secretary.

Method.

The method of applying the Job Plan is to follow each phase in sequence. It will be more apparent later, especially when tried for the first time, that the phases are highly dependent upon each other. Therefore, it will occasionally be necessary to return to a previously completed phase for additional data needed for a downstream decision.

Judgment must be exercised to determine the depth to which each phase should be performed before proceeding to the next step. A trade exists between doing work that may turn out to be unnecessary and jeopardizing the complete success of the following phase due to incomplete performance of the precedent. This judgment is a skill factor that is improved by experience.

Phases of the Job Plan.

As noted before, the nomenclature of value engineering is not universally constant. Most, if not all, of the differences are not significant enough to be an issue. Especially in a training mode, it is the understanding of the intent that is the prime objective. This Guide presents the Job Plan in five steps or phases:

A. Information Phase

1) Gather facts
2) Analyze functions
3) Prepare cost model
4) Set cost target

B. Speculative Phase

1) Develop possible alternative solutions

C. Evaluation Phase

1) Analyze alternatives, compare with the criteria
2) Determine implementation costs
3) Select most likely alternative
4) Verify adequacy of selected alternative

D. Proposal Phase

1) Determine recommendations
2) Prepare written report

E. Implementation Phase

1) Follow up and assist in the implementation of recommendations
2) Verify predicted cost data

Information Phase. This is the first step in the Job Plan. Its objectives are to: a) obtain a complete understanding of the project supported by factual knowledge and b) establish the criteria against which possible improvements will be compared.

The first objective is gained by gathering information. (For training exercises much of this should have been performed in advance and provided to the team. This task is suitable for assignment of separate parts to individual team members. The data gathered should be supported by tangible evidence in the form of copies of the applicable documents. Typical

information which should be obtained includes the following (the type of project will influence the final choice):

A. Design
   1) Drawings
      a) Layout
      b) Fabrication
      c) Assembly
      d) Control
      e) Interface
   2) Specifications
   3) Background of previous design decisions
   4) Schedule
   5) Tooling

B. Customer and Contractual Requirements
   1) Quantity and schedule
   2) Specifications
   3) Application
   4) Incentives
   5) Procurement potential
   6) Previous procurements
   7) Change procedure and requirements
   8) Proposal data

C. Fabrication and Test
   1) Make or buy data
   2) Tooling data
   3) Manufacturing planning
   4) Schedule
   5) Vendors or subcontractors
   6) Reject or scrap rate
   7) Quality program
   8) Test procedures and past results
   9) Packing and shipping
   10) Sample item
   11) Process specification

D. Cost Data (input to and as defined by cost model)
   1) Historical actual costs
   2) Estimated future costs
   3) Proposal costs
   4) Contractual costs

When facts based upon documentation can not be obtained, seek the opinions of knowledgeable personnel. In all cases go to the best source. For instance, contracts personnel are better qualified to interpret the contract than the designer; written reject records can provide better data than the foreman who may have forgotten or who may have come on the job after the fact; manufacturing planning may show several intermediary operations that were not contemplated by the engineer.

The second objective, to establish the criteria for later comparison with alternatives, is gained by: a) analysis of function, b) preparation of a cost model, and c) setting cost targets. Functional analysis has been previously discussed. Cost models and cost targets will be presented in

Chapter 3 and Chapter 4. If the study is a team exercise, all members should participate in the performance of the functional analysis. The preparation of the cost models and cost target may be assigned to an individual. All team members should be given copies of the models and should concur with the cost target.

Speculative Phase.

The objective of this phase is to develop possible solutions to the value problem. Consideration of solutions should not formally begin until the problem, as defined during the Information Phase, is well understood. All team members should take part in the execution of this phase. The choice that is selected by the study, and hence the results of the exercise, will probably be generated during this phase. The generation of alternative approaches to performing the needed functions may be done by several problem solving systems. If the item under study has more than one feasible solution, the likelihood of finding the best one increases with the number of possible solutions generated. Formal use of the creative problem solving process is suggested to produce possibilities other than those that might occur spontaneously or by any other process. Techniques for its application to this sort of problem are given in the next section of this chapter.

Evaluation Phase. In this step the choices developed in the preceding phase are sifted and examined to arrive at a final recommendation. The process involves a verification of the probability of satisfactory substitution for the subject under study. This will probably not be required in detail for each of the generated alternatives, since many of them will be disqualified after a superficial examination.

The most likely candidates should be subjected to the following operations which may be performed by separate members of the study team:

A. Functional Analysis

B. Detailed Cost Estimate

1) Unit Cost
2) Implementation Cost
3) Contract Cost Effect

C. Technical Adequacy Status

1) No testing required, or
2) Testing required

a) schedule
b) cost

D. Change Procedure Requirements

The assessment of the above data should indicate a most likely choice. Two selections may be made if the analysis doesn't provide a clear decision. For example, an alternative which requires an extensive testing program may be recommended together with another choice which offers a lower cost reduction but which does not require verification.

Actual testing is not usually a part of the value engineering process, per se. Simple or inexpensive testing may be "fitted in" as the Job Plan is followed. The value engineering objective is to analyze, study and recommend for action. Neither its budget nor its capabilities are usually organized for engineering verification.

Proposal Phase. In this phase a report is prepared of the study activities, results and recommendations. Each team member should contribute a portion, but each need not prepare a separate report. The report, called here a value engineering proposal, is directed to the authority or agency which convened the group or authorized the study. Additional distribution of the report should be made only by its recipient.

The report should be prepared in a style consistent with the standards of good technical writing. Three special considerations should be noted:

a) A one-page summary of the entire report should be the first page of the report. It should contain the highlights of the study, the recommendations and a concise treatment of the cost data.

b) The flavor and tone of the report should be carefully designed to avoid alienating other personnel. No matter how tendered, the value improvement recommendation is a criticism. It is offered constructively, but it is sometimes viewed otherwise.

c) Complete back-up details of names, prices, sources, document numbers, etc., must be provided. The implementation personnel should be able to readily locate key information.

Implementation Phase. The responsibility of a team is discharged when the report is issued. Attainment of the overall objective is not however, reached until the recommendations are converted into actions. Assigned value engineering personnel should remain active on the study until it is implemented or has been satisfactorily disposed. Assistance may be needed in the change procedure, reverification of elements of the proposal, provision of further back-up data, etc. The actual costs of implemented studies should be determined for comparison with the proposals.

CREATIVE PROBLEM SOLVING

The application of value engineering involves many parameters such as size, weight, function, cost and other related and sometimes seemingly, unrelated factors. These factors must be established, quantified and so arranged that they offer the best value for the application at hand. The process solving this problem may proceed by an analytical progression of events and ideas to a single answer; or, a creative approach may be taken which leads to many answers, any or all of which may be possible solutions.

Analytical Approach.

The strictly analytical approach is substantially singular in purpose. The problem is stated exactly. A direct approach to the solution is taken which proceeds through a step-by-step progression of experiments, evaluations, mathematical manipulations and arrives at a single answer. An analytical problem is one that has only one solution that will work.

For example, several metal racks each containing a number of cabinets or drawers of electronic equipment are installed in a large room. Excessive operating failures have resulted in loss of operating time and costly maintenance. "Find the cause of the failures." is an analytical problem. One pursues the problem through a progression of suppositions to be proved or disproved by experimentation, tests, calculations, etc., until the problem is successfully narrowed to a single cause for each failure. Once the cause is ascertained, that problem is solved.

Creative Approach.

A creative problem is one that has more than one workable solution. The creative approach is an idea-producing process intended specifically to generate a number of solutions, each of which will solve the problem

at hand. Some of the answers are better than others, but all will work. One is better than all the others; it is the optimum solution among those available. The best solution to the problem may not even have been generated.

In the electronic equipment example cited above, the situation posed by, "excessive failures that resulted in loss of operating time and costly maintenance," may be resolved into two problems: a) Determine the cause of failures (analytical problem), and b) Prevent re-occurrence (creative problem).

The cause was found to be the generation of heat by vacuum tubes. A number of electronic components then failed as the temperature of the surrounding trapped air rose. What is the solution to this portion of the problem? A number of ideas may be proposed:

a) Keep on hand a spare supply of components. Replace whenever failure occurs.

b) Replace the failure prone components with others that have higher heat-resistant capabilities.

c) Install a refrigeration unit to provide cooling air inside the racks.

d) Control the temperature of the entire room by installing an air conditioning unit.

e) Eliminate the vacuum tubes and replace them with nonheat producing components such as transistors.

f) Equip each rack with an electric fan to dissipate heat by forcing a flow of cool air past the vacuum tubes.

Any of the above would solve the problem. One of them is better than the rest. Its selection is an analytical problem. But the best solution that could be found may not even be on the list.

Creativity.

Creativity is a complex thought process of generating ideas and images. It is a capability that everyone possesses to a greater or lesser extent. The creative ability is analogous to other mental abilities, such as memory, in that we tend to use only a portion of our latent capacity. The remainder lies dormant in many people. Unfortunately, the experiences of life that

accrue with the passage of time that brings maturity generally acts to submerge the inherent creative capability.

Application.

The problem posed by a value engineering study is a creative problem. Many of the cost-incurring decisions in the defense environment have several workable solutions. As shown before, the probability of finding the best solution, the one that represents the best value, increases with the number of solutions developed. Creative problem solving is a method of generating many possible resolutions. It finds its application primarily in the generation of alternate approaches to the project under study. It is offered as an aid to performing the Speculative Phase of the Job Plan.

Human Factors.

The success that one has with the creative problem solving techniques will improve with practice. Before starting, it is necessary to understand the interplay of certain mental habits and attitudes. Some are conducive to creative thinking and others inhibit new thoughts and ideas. There are a number of mental traits which provide positive support for creative thinking. Some of these are: a) sensitivity, b) curiosity, c) persistence, d) inquisitiveness, e) constructive discontent, f) initiative, and g) flexibility of thought.

It is commonly believed that these are innate qualities which cannot be improved or developed. This is not so. The human mind has a measure of flexibility similar to the muscles of the body. Conscious exercise of these beneficial traits will develop them until they become as much a part of the subconscious thinking process as any habit.

There are other mental attitudes which tend to inhibit creative thinking. Commonly called mental blocks, these may be categorized as a) perceptual, b) cultural, c) emotional, and d) habitual.

A. Perceptual Blocks

1) Failure to use all the senses for observation.

2) Failure to investigate the obvious.

3) Inability to define terms.

4) Difficulty in visualizing remote relationships.

5) Failure to distinguish between cause and effect.

B. Cultural Blocks

1) Desire to conform to "proper" patterns, customs or methods.

2) Overemphasis on competition or on cooperation.

3) The drive to be practical above all things -- too quick to apply judgment.

4) Belief that all indulgence in fantasy is a waste of time.

5) Faith only in reason and logic.

C. Emotional Blocks

1) Fear of making a mistake or of appearing foolish.

2) Fear of supervisors and distrust of colleagues and subordinates.

3) Overmotivation to succeed quickly.

4) Refusal to take any detour in reaching a goal.

5) Inability to reject decisions which are adequate but which are obviously suboptimum.

D. Habitual Blocks

1) Constant search for solutions to new problems by the same methods without questioning the adequacy of the old methods.

2) Continuing to use "tried and true" procedures even though new and better ones are available.

3) Rejection of alternate solutions which are incompatible with habitual solutions.

There are three levels of thinking that need to be recognized:

a) <u>Habit</u> - Continuous usage of sameness in thought and action that results in good habits and bad habits - requires little, or no, conscious reflection.

b) <u>Insight</u> - Rapidly occurring understanding, discernment, judgment or assessment.

c) <u>Creation</u> - Generation of responses unhindered by mental blocks and premature judgment.

All three levels of thinking may contribute to creative problem solving. The creative process will, in the long run, produce more, and probably better, solutions.

Techniques.

There are more than a dozen techniques available for use in creative problem solving. Several of the more generally applicable ones will be discussed here. Some are for use by individuals working alone and some are intended for group exercise. Certain of these methods were created for application to particular categories of problems, or for problems peculiar to one industry, or for certain skill levels of the personnel who will use them. All provide a routine of mechanical procedures to help the user generate more solutions to his creative problems.

The various techniques provide formats for mental stimulation. It is necessary, during their usage, to conscientiously think creatively. The ground rules to be followed may be summarised as:

a) Do not attempt to generate new ideas and to judge them at the same time. Separate these aspects in time, certainly, and in place and by personnel if possible.

b) Generate a large quantity of possible solutions. Multiply the number of ideas produced in the first rush of thinking by five (or by 10) to set a goal for the desired quantity.

c) Seek a wide variety of solutions that represent a broad spectrum of attacks upon the problem.

d) Watch for opportunities to combine or improve ideas as they are generated.

e) Before closing the book on possible solutions allow time for subconscious operation on the posed problem while consciously performing other tasks.

Delineation of Features. There are several creativity techniques which are based upon separate or combinational arrangements of the individual attributes of the project under consideration. In its simplest form, each feature, facet or physical parameter of the subject is separately listed. These are examined and considered, one at a time, as possible mental stimuli and as bases for combination or improvement.

A sophistication of this technique is to arrange the attributes vertically down the left side of a piece of paper and then horizontally across the top. The intersections of the horizontal and vertical columns represent all possible combinations of each attribute with one other. These combinations may stimulate additional ideas. Three-way combinations using a list along a third mutually perpendicular axis may also be developed.

Forced Comparisons. This technique is a means of forcing comparison between the subject and an arbitrarily selected object. The object can be selected at random from a hardware catalog, from among the articles in view at the moment or from any other convenient source. The selected article and its features are considered with respect to the subject for which alternates are desired. This will provide additional stimuli for ideas. For instance, a telephone might stimulate some thoughts about a sheet metal packing box which is under study: a molded plastic box, different colors for different contents or destinations, used discarded telephone packing boxes, etc.

Inputs and Outputs. This technique is used where the problem involves a known input or work effort that is to produce a specified output or end result. The procedure is to examine methods of using the input to cause the output directly. This method is typically applicable to problems which involve some form of energy, as shown by the following example.

A low-lying area of homes and shops is located at the base of a dam across a part of a river about 2, 000 feet above the low-lying area. There is a lake of water held behind the dam. Periodically, melting snow precariously raises the water level of the lake to such an extent that water spills over the dam and floods the area below. A method of warning and control is required.

High water is the input and flood is the output. First analyze the input -- high water. How can the rising water, or its effects, provide a method of controlling the water? What outputs are produced directly by the input? The outputs can be: a) water level changes, b) increase in weight of water at bottom of dam, c) submerged and dampened dry land at the upper edge of the lake, etc. Utilizing these outputs, a number of solutions may be derived: a) install a transducer below the low water level that will trigger a warning signal or open a spillway at a pre-set high

water level; b) place stakes with stripes of high visibility paint of various colors at the edge of the lake to provide a visual means of determining the water level in the lake; c) place an "open" electrical circuit at a normally dry position on a bank of the lake that will close upon submergence to provide a warning signal.

Group Association. This method in its numerous variations is based upon the stimulation of one person's mind by another's. Two people working together under the ground rules described earlier can generate more ideas than either one alone. This is mostly due to the ideas gained by one as variations or improvement of ideas expressed by the other. The efficiency of the group goes up as its size increases above two until it reaches the point where its operation becomes so cumbersome as to discourage some members' participation. Groups of about ten are about the largest practical size for this type in value engineering application.

The members of the group may be selected to represent different work backgrounds. Some should have a working familiarity with the subject under study. They need not all have known one another before the session. All should come from equivalent strata of the organization. An executive may have an emotional block if very junior personnel are present and vice versa.

A group leader operates the session by posing the problem. He recognizes the members who have solutions to offer. A secretary or tape recorder notes each idea. It is important not to exercise critical judgment of any offered idea during one of these sessions. Critical judgment will tend to inhibit the thinking of the judged and will have a stultifying effect upon the others.

METHODS AND PROCEDURES: SUMMARY

A. The application of value engineering requires the analysis of functions, the assessment of their relative need and the comparison of their worth to the cost of their achievement.

B. Basic functions are those performance features that need to be attained in the application under consideration.

C. Secondary functions are an item's performance features that need to exist for the item to perform its basic function(s).

D. The worth of each basic function is set as the criteria to test the cost of various methods of accomplishing the basic functions.

E. Formal accomplishment of the steps in the Job Plan will assure comprehensive consideration of the key elements of value engineering.

F. The input to the Job Plan is an item selected for value assurance or value improvement study and the output is a report of recommendations concerning the item.

G. A comprehensive written record should be maintained of the tasks performed and data gathered in each phase of the Job Plan.

H. Each person can significantly improve his capability to generate solutions to problems by understanding the associated thinking processes and the observance of a few ground rules.

I. The probability of finding the best solution increases with the number of solutions considered.

J. The generation of large numbers of possible solutions is facilitated by: a) separating the generation and judgment of solutions, b) maintaining acute cognizance of possible mental blocks, c) consciously seeking a broad spectrum of types of solutions, d) allowing time for subconscious exercise of the problem while consciously performing other tasks, e) using formal methods of artificially stimulating thought, f) examining all posed solutions for combinations and improvements, and g) the deliberations of a small group of selected persons.

Chapter 3: Cost Visibility

The performance of value engineering and the application of its principles requires knowledge of costs in every situation.,.This Chapter explains the processes of industrial cost estimating...the use of learning curves...and standard hours in the estimating process...The extension of direct costs into total price by application of overhead...G & A...and profit is described...Several techniques are offered for evaluation of cost reasonableness ...cost modeling is introduced as a method of improving cost visibility in value engineering application...The selection of cost model elements...format...and construction is explained by example.

CHAPTER 3

COST VISIBILITY

The need for cost knowledge is directly related to the cost oriented definition of value engineering--the achievement of needed function as minimum cost. This need is apparent in many areas. As a value engineering study is pursued and as the method is used in daily decision making, the question, "What does it cost?", occurs repeatedly. Satisfactory completion of the Job Plan Information Phase required information about the functional requirements and detailed cost information about current or anticipated approaches to satisfy these criteria.

Design decisions are among those that have a major affect upon final product cost. The relative cost effects of a wide range of design alternatives must be available if a high value product is to be assured. This applies to the "design" of software as well as hardware. Cost conscious personnel and value engineering personnel are concerned not only with what can be done, but with what should be done to reliably provide the required function at minimum cost. The methods, nomenclature and procedures associated with cost are not standardized in the defense industry. This Chapter will offer a basic understanding of the general process.

COST ESTIMATING

Cost estimating is the process of forecasting the lowest level of cost associated with the performance of a given task. It represents a prediction of what the actual cost will be when the task is completed. It usually includes, but is not necessarily limited to, direct labor time, material items, travel, technical data and packaging. The cost estimate, through

a further process called pricing, is extended by the application of labor rates, overhead, other business costs, and profit. Price is the dollar amount which a customer pays. Price represents the acquisition cost of defense inventory items. The cost estimate is the base for the price--any errors in the base tend to be magnified in the price.

Estimating is largely a subjective process of personnel judgment for items under development. When additional quantities are procured, the subjective estimate may be modified by application of historical actual cost data from cost accounting records.

Accuracy of the Estimate.

The degree of accuracy of a cost estimate varies as a function of a) the item's "maturity," b) the time available to prepare the estimate, c) the state-of-the-art of the item, d) the existence of definite specifications, and e) the availability of related historical cost accounting data. Estimates for the cost of items in the conceptual stage are not as accurate as those based upon completed engineering drawings. Even when drawings exist, an item that has never been produced is less amenable to accurate cost estimation than one previously manufactured. The net effect of these and other contingencies is that estimating is difficult under optimum conditions, and that any deviations from the optimum usually degrade cost estimate accuracy.

Cost Breakdown.

One of the most effective ways to gain a comprehensive view of the cost estimating and pricing process is to examine the individual cost elements which make up a complete pricing package. Figure 3-1 shows the front side of Form DD633, Cost and Price Analysis. This guide will use it as an example of cost elements in a selling pr. e. (The reader should become familiar with the specific forms and pricing structure pertinent to his agencies procurements.)

Direct Material. This is all material anticipated to be required for performance of the work being priced. The principal categories of material (and some typical examples) are:

DEPARTMENT OF DEFENSE COST AND PRICE ANALYSIS	NOTE: For cost type proposals, only the TOTAL column need be used unless requested otherwise by the contracting officer. If your cost accounting system does not permit analysis of costs as required below, contact the purchasing office for further instructions.	Form Approved Budget Bureau No. 22-R100

NAME OF OFFEROR			PREVIOUS CONTRACT FOR SIMILAR MATERIAL	
HOME OFFICE ADDRESS			CONTRACT NUMBER	
			QUANTITY	
DIVISION(S) AND LOCATION(S) WHERE WORK IS TO BE PERFORMED			ACTUAL MANUFACTURING PERIOD (Exclusive of Preproduction)	
SUPPLIES AND/OR SERVICES TO BE FURNISHED			FROM	TO
QUANTITY	AMOUNT OF PROPOSAL	PROCUREMENT DIRECTIVE NUMBER	PEAK RATE PER MONTH	

ITEMS 1/	PROPOSED CONTRACT ESTIMATE			PREVIOUS CONTRACT ACTUAL UNIT COST 1/ 2/
	PREPRODUCTION 2/	PRODUCTION 2/	TOTAL	
1 DIRECT MATERIAL				
PURCHASED PARTS 3/				
SUBCONTRACTED ITEMS 4/				
OTHER 5/				
2 DIRECT ENGINEERING LABOR (Attach breakdown)				
PREPRODUCTION HOURS / PRODUCTION HOURS / OTHER HOURS				
3 ENGINEERING BURDEN % of 2				
4 DIRECT MANUFACTURING LABOR (Attach breakdown)				
PREPRODUCTION HOURS / PRODUCTION HOURS				
5 MANUFACTURING BURDEN % of 4				
6 OTHER DIRECT COSTS 6/				
7				
8				
9 SPECIAL PLANT REARRANGEMENT				
10 OTHER INDIRECT COSTS 6/				
11				
12				
13				
14 SUBTOTALS				
15 SELLING EXPENSES				
16 GENERAL AND ADMINISTRATIVE EXPENSES				
17 SUBTOTALS				
18 PROFIT OR FEE				
19 ROYALTIES 7/				
20 CONTINGENCIES 8/				
21				
22 FEDERAL MANUFACTURERS' OR RETAILERS' EXCISE TAX 9/				
23 UNIT SELLING PRICE OR TOTAL CONTRACT PRICE EXCLUDING SPECIAL TOOLING (14-22)				
24 SPECIAL TOOLING COST FROM REVERSE SIDE OF FORM				
25 UNIT SELLING PRICE OR TOTAL CONTRACT PRICE INCLUDING SPECIAL TOOLING (23-24)				

DD FORM 1 APR 61 633 (See Reverse Side)

Figure 3-1. Cost and Price Analysis -- Form DD 633

A. Raw Material

(Bar stock, sheet metal, tubing, and similar material processed "in-house" so as to lose their original dimensions or properties.)

B. Purchased Parts

(Castings, forgings, transistors, transformers, valves, and a wide range of standard and semi-standard components which will not lose their identity in the end product.)

C. Subcontracted Items

(Complex components or major subassemblies which are procured by contractual arrangement with an industrial firm.)

Direct Labor. This includes all labor hours estimated to be expended specifically to produce the product or service being supplied. The draftsman who prepared one of the product drawings is a direct charge; the cost of the machine operator who reproduces that drawing and others from several contracts is not. Direct labor hours are estimated by categories. The direct labor categories for design and production usually include those below. As previously noted these arrangements are not standardized.

A. Engineering

1) Technical staff members (engineers, scientists, etc.)
2) designers and draftsman
3) laboratory technicians
4) secretaries
5) technical writers

B. Fabrication

1) model shop machinists
2) sheet metal shop operators
3) plating and processing operators
4) machine shop machinists
5) foundry workers
6) planning and scheduling personnel

C. Assembly

1) model shop assemblers
2) mechanical assemblers
3) electronic assemblers

D. Test and Calibration

1) Tooling

a) designers
b) tool fabrication machinists
c) tool proofing operators

Standard Hours. Manufacturing labor is sometimes estimated by the "standard time" method. A standard time interval, usually expressed in hours, is the amount of time required by the average worker, working at a normal pace, under average conditions, to accomplish a particular task. Standard hours are normally used for costing production quantities. They are developed from measurements and actual records of individual labor operations such as drilling holes, stamping parts, and soldering electronic components.

Once the standard time has been set for the various fabrication operations, they serve as data inputs to the costing of new jobs. The estimator adds up the standard hours for each fabrication step defined by the planning. He applies factors which allow for fatigue, rest, lost time, and for realization rates of most recent occurrence. This converts standard time to actual time. The pricing extension is developed from the standard hour base as shown in Figure 3-2.

Other Direct Costs. Direct costs are the base for price in most defense industry pricing structures. Frequently, it is desirable for industry to include as many cost elements as possible in the direct category. Department of Defense regulations provide for the allowability of items of direct cost under various circumstances. It is not possible here to provide a list of all other direct costs that may be involved. Some of them are: a) tooling, b) special engineering, c) travel costs in excess of the labor time, such as airplane fare, meals and hotel, and d) other elements which may be usually charged to overhead but which must be especially modified or priced for the task being estimated. An example of the latter is a special and extra expensive, shipping carton. It may be charged direct because it is special for one case even though the cost of regular shipping cartons is provided for in overhead. Other items of direct cost may be estimated in lump sums rather than synthesized on a "per unit" basis, e.g., set-up labor time on machinery.

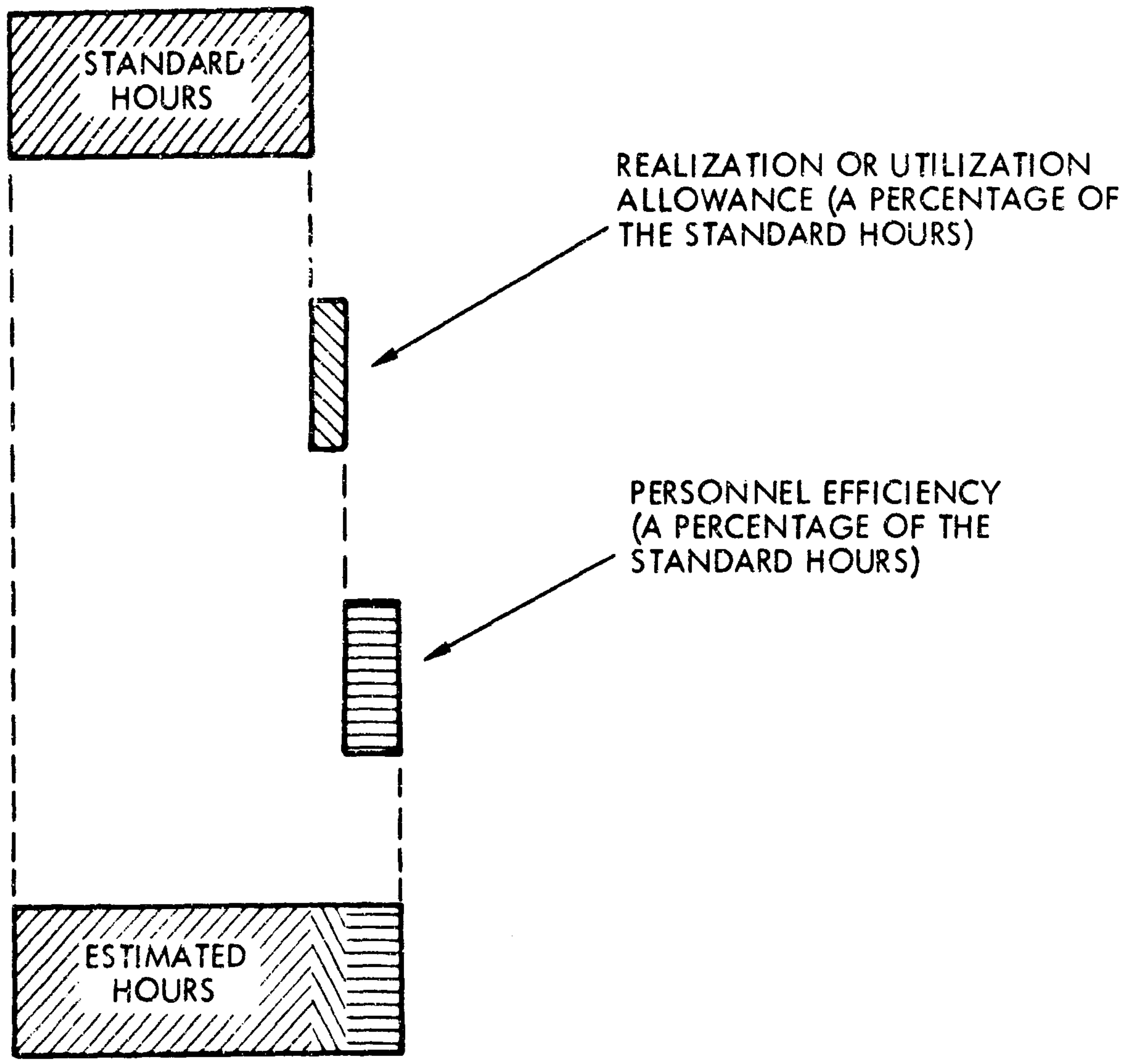


Figure 3-2. Estimating Labor Hours from Standard Hours

Overhead. In addition to the material and labor costs which can be directly attributed to a product or service, there are various indirect costs. One category is commonly called overhead or burden. This includes items not directly attributable to the actual part being estimated but which are necessary for the overall sustenance of the organization. For instance: a) the wages of employees who do not work directly on producing the end product, b) office supply costs, c) plant maintenance costs, d) taxes, e) depreciation, f) telephone costs, and g) employee fringe benefits (vacations and sick leave) may be included.

The type of contract and pre-determined arrangements with government auditors determine which cost elements will be included in the overhead and which in the direct category. Overhead costs include those which occur regardless of business volume (e.g., rent) and others which vary with the plant's volume (e.g., utilities). Overhead costs in large installations may be collected separately for various organizational units. These are usually identified as load or overhead centers. The number of these centers depend upon factors such as the grouping of direct labor rates, types of machinery or equipment, etc. A shop with expensive machine tools will usually have higher overhead costs than an assembly area where many hand operations are performed. For cost accounting or estimating purposes these load centers are considered as distinct sections of the plant. They are identified by code numbers and all costs incurred, both direct and indirect, are accumulated. These centers may be treated in groups to develop overall cost estimating data.

Determination of Overhead Rates. Direct and indirect costs are collected over a period of time for each cost center. The ratio of indirect cost to direct cost are computed. These percentages are reviewed and annually negotiated between the Government and its defense contractors. The approved figures, possibly modified to reflect expected future variations, are expressed as percentages. For example, Company X may have an approved overhead bidding rate for the next six months of 115 percent. The overhead cost that would then be added to the estimated total direct cost base would be 115 percent of the direct cost. As prescribed by the Armed Services Procurement Regulation (ASPR), overhead costs are not always added to some of the direct cost elements. For example, outside

purchased parts and subcontracts costs are priced without adding the overhead rate. In certain cases a percentage factor lower than the overhead rate may be allowed to cover the costs of "handling."

General and Administrative Expense (G & A). Some costs which are not included in direct or in overhead are grouped under G & A. These vary among organizations, but generally include the costs of: a) legal, b) finance, and c) corporate executive salaries. These costs are collected, negotiated and generally treated similar to overhead; the G & A rate is expressed as a percentage. The total of direct and overhead plus those items of direct to which overhead is not added is multiplied by the G & A percentage figure. This amount is added to the sum of the direct and the overhead in the pricing process.

Profit and Fee.

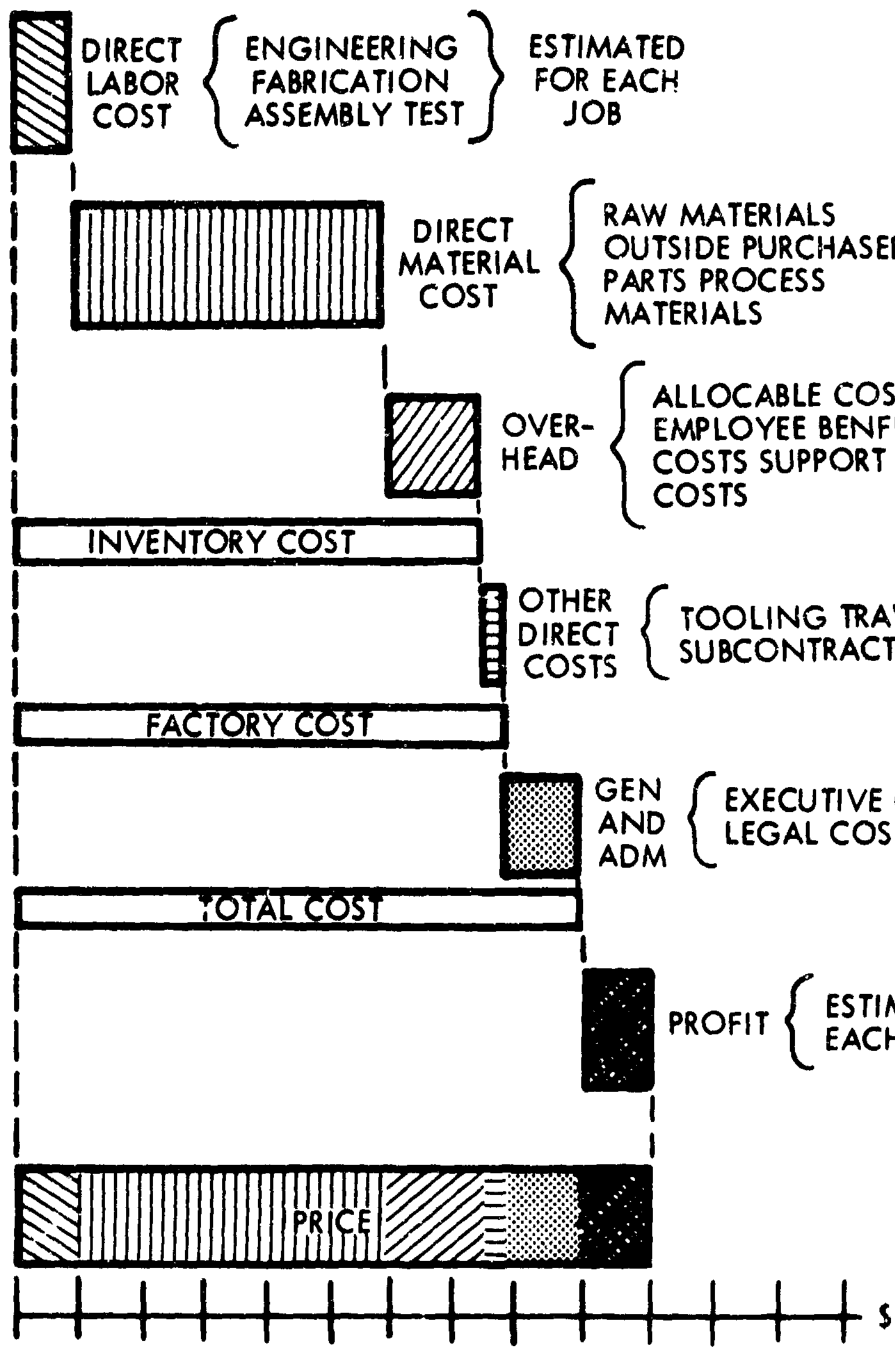
Profit (called fee for cost reimbursement contracts) is computed and added to total estimated cost. Department of Defense regulations, mandatory as of 1 January 1964, provide weighted guidelines to determining allowable profit on all negotiated defense contracts. The objective of these guidelines is to relate the amount of profit to risk and excellence of performance. The determination of the amount of profit is accomplished by assigning a numerical weight range to a number of factors:

a) the record of past performance.
b) the degree of engineering or special achievement required.
c) the extent of contractor risk.
d) the amount of contractor resources to be applied.
e) the difficulty of the contract task.

Contractors are expected to use these guidelines in framing their profit objectives for anticipated work, prior to negotiation. The proposed profit is then negotiated.

Price. The resultant of the estimating and pricing process is the selling price. The buildup of price from the direct, material, overhead, G & A and profit is illustrated in Figure 3-3.

Cost Accounting. Cost accounting is the process of recording actual costs as they are incurred. For value engineering purposes it is most effective when it provides data for use in cost forecasting. To use cost accounting data for this purpose, the actual costs must be collected by jobs or cost



THE ARRANGEMENT PRESENTED HERE IS A TYPICAL ONE; ACTUAL INDUSTRIAL PRACTICES VARY IN DETAIL AND IN NOMENCLATURE

Figure 3-3. Elements of Cost and Price

centers in a form that permits application in the estimating process. The data must be timely and economically retrievable. At the present time, cost accounting data is used mostly for other purposes, such as the fiscal operations of billing, tax computation and corporate finance decisions. The collection formats for these uses generally do not lend themselves directly to cost visibility usage in value engineering.

Learning Curves.

As the production of an item proceeds in quantity the unit labor cost decreases. This is a normal by-product of good production practices and operation planning. The decreases reflect learning on the part of operators and management personnel and is manifested in reduced time to perform repetitive tasks. Analysis of the World War II aircraft industry revealed that there was a constant rate of learning for various fabrication processes. Many studies since then have shown that the same phenomenon applies to the fabrication of missile hardware, weapons, and commercial products.

The law of the learning curve may be generally stated that as the production of an item proceeds, its unit labor cost is less by a fixed percentage every time the produced quantity is doubled. The exact percentage depends upon the item and the kind of labor. Applicable percentages for various cases are developed from historical cost accounting data.

Applications of Learning Curves. As shown in Figure 3-4, a plot of unit labor cost versus the serial number of quantity produced is a straight line on log-log graph paper. The slope of the curve is indicative of the decrease in the cost with the increase in the produced units. Typically, learning curves are expressed as a percentage figure that is expected to apply to a given process or situation. For example, if it is said that an 80 percent learning curve is expected for a certain design, it means that the cost of an item will decrease by 20 percent every time the quantity is doubled. The cost of the 50th item will be 80 percent of the cost of the 25th item, and the cost of the 100th item will be 80 percent of the cost of the 50th item. Note, therefore, that it is only necessary to know (or to estimate) the time or cost of producing one article and the applicable percentage factor and one can predict the cost of any quantity.

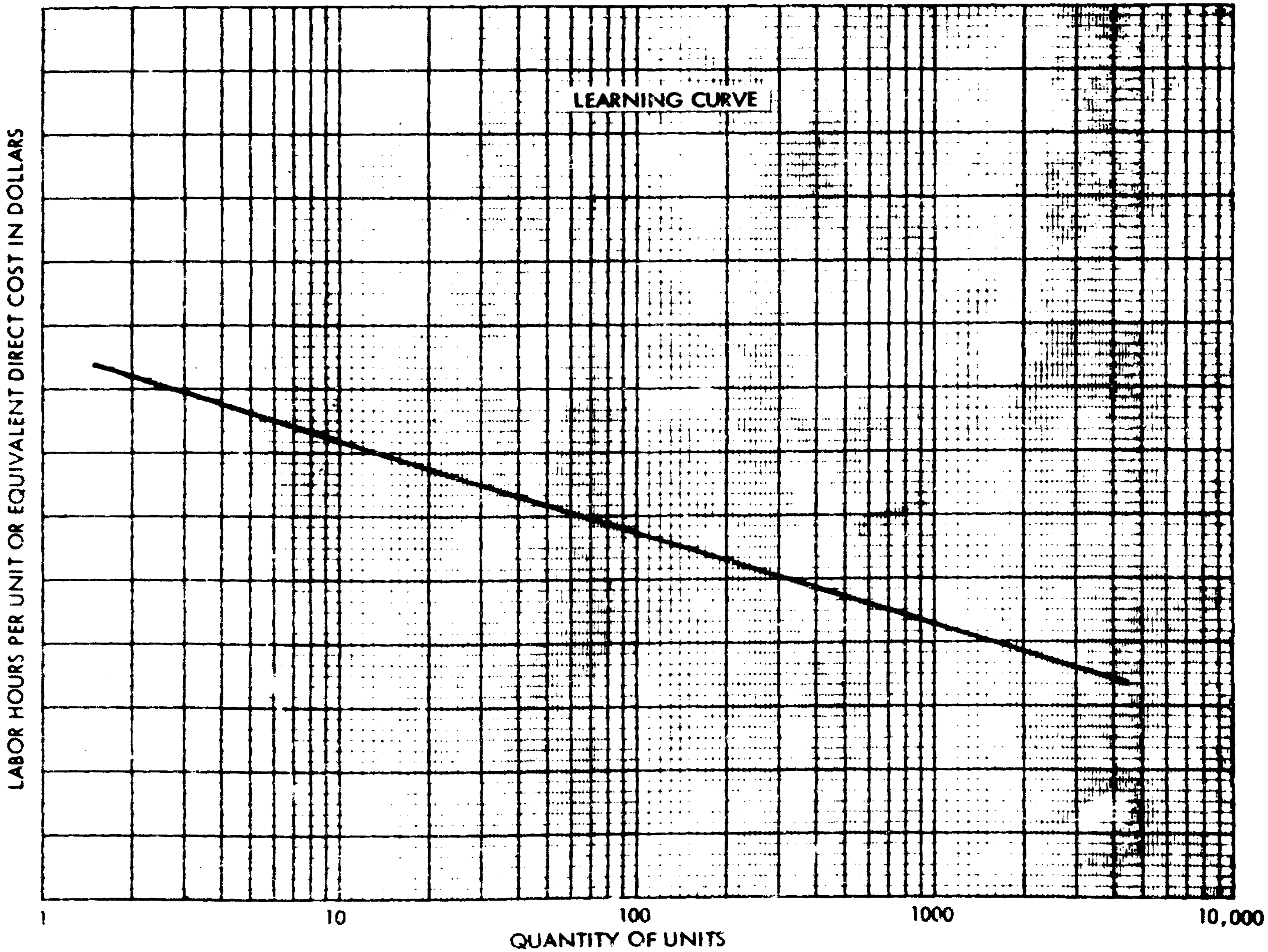


Figure 3-4. Learning Curve

The production time reduction as the produced quantity doubles is disturbed if the item is changed. The rate of reduction (slope of the learning curve) may remain the same but the quantity starts over again from item one of the changed article. In effect, the learning has to be learned all over again. The cost goes back up the learning curve to some new number of hours. A new slope may prevail if the change uses a process which has different learning characteristics. Thus, the decision to select items as likely to produce savings, the selection of alternative items and the presentation of the cost data should reflect consideration of the projected fabrication cost of the present article and the perturbations introduced by disturbing or discarding the achieved learning. The place in the production schedule where the anticipated change is to be made may be different for several possible alternative items. The cost consequences of varying the proposed change effectivity in the production schedule can be estimated with the aid of the learning curve.

Limitations and Restrictions. One of the possible misuses of learning curves is that there are other elements besides direct labor which make up total product cost. It may be a mistake to assume that labor efficiency has been increased when certain items previously made in-house are shifted to a "buy" basis. Although such a situation may be arithmetically demonstrated as "make" cost versus "buy" cost, it may represent a loss if the arithmetic did not consider the learning to be gained in-house.

Another pitfall is where the price of a job is based upon the learning curve and then the desired slope is not achieved. Production goals commensurate with the learning curve labor reductions must be set and responsibility for meeting them delegated to the appropriate supervisory level.

The attempt to reduce direct labor cost at the expense of either tooling or engineering can be fallacious. It would, for example, be unreasonable to acquire a $500, 000 automated machine unless the learning curve for the manual process had been examined. Future learning could reduce the unit item cost to the point of offsetting the tool cost.

COST ANALYSIS

Cost analysis, as presented in this Guide, represents a rapid assessment to determine the reasonableness of item cost. It is another facet of improving cost visibility. Useful tools for cost analysis of alternate design configurations have been developed in many different industries and cover a wide diversity of products.

Charts, tables, formulae, and graphs express ratios of one or more product cost elements (for example, prototype or production engineering, raw materials, purchased parts, or qualification tests) related to some other product characteristic (for example, size, weight, capacity or power output). These tools serve as effective aids in the identification of items of relatively high or low value. Additionally, they provide a rapid method to check the cost reasonableness of designs as they are developed, procured, and examined for re-procurement. Some generalized examples will be presented below to illustrate the possibilities.

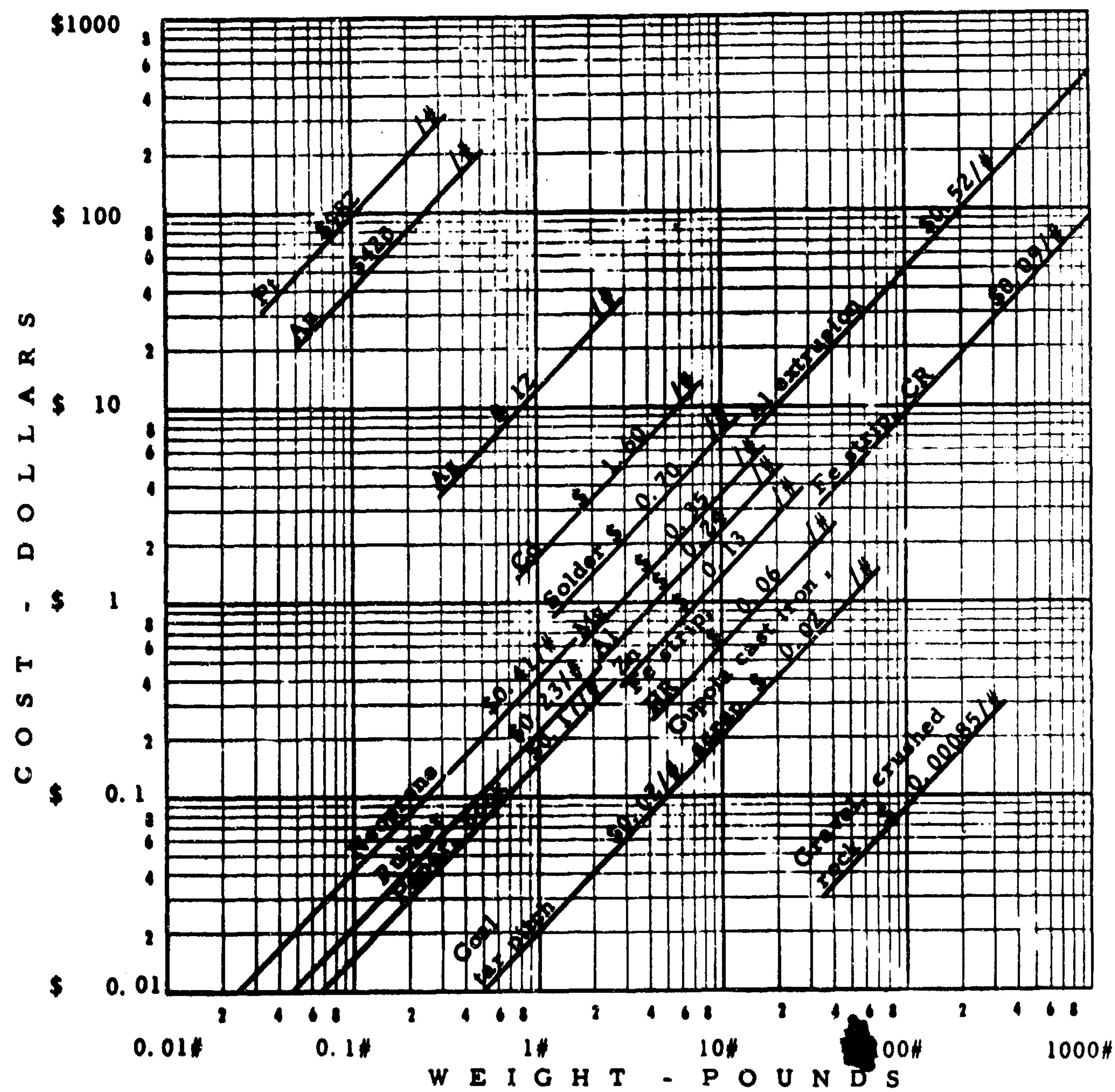
Costs Per Unit of Weight. Figure 3-5 relates cost to weight in pounds for a number of basic materials. This same type of chart may also be prepared to apply to assemblies, and even complete products, thereby enabling weight to provide an order-of-magnitude cost figure. It is possible, for example, to compare the cost per pound of a proposed design with other similar items which are considered to represent good value. Such comparisons highlight abnormal costs and direct more concentrated attention.

Costs Per Unit of Area. Figure 3-6 shows an example of cost versus area for a variety of items. Similar graphs may also be prepared for any item whose configuration is characterized by surface area.

Cost Per Unit of Length. Figure 3-7 shows an example of cost versus length for various common materials. Information obtained from a chart of this type may be used to compare the cost of material being considered (on a per unit of length basis) with other types of material, thereby highlighting excessive costs and stimulating additional study to locate acceptable lower cost materials.

Costs Per Unit of Volume. Figure 3-8 shows an example of cost versus volume for representative solid materials. Similar graphs may also be

Cost Reference: U. S. Dept. of Labor, 1962

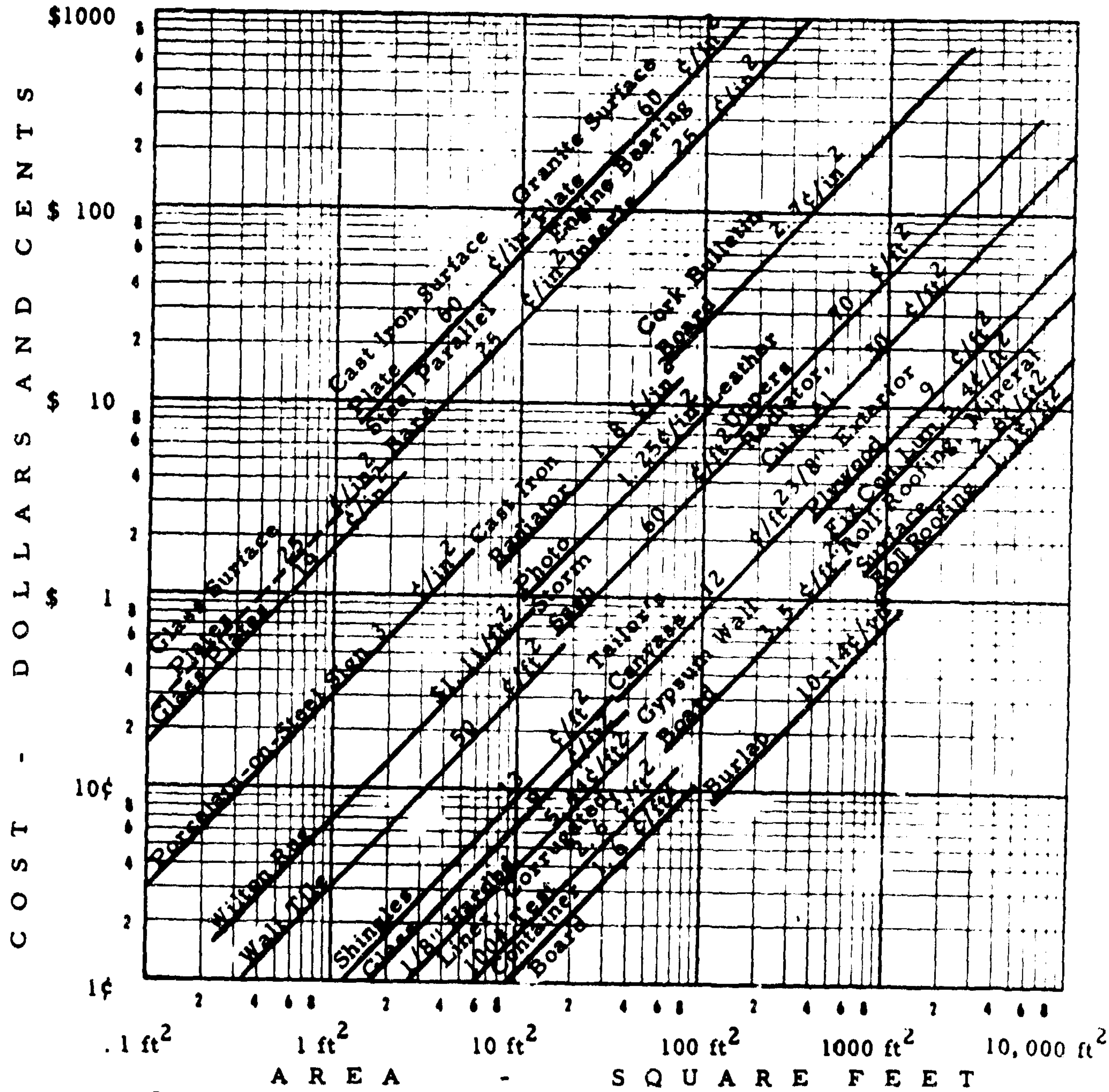


#	= pound	Al	= aluminum
Pt	= platinum	Zn	= zinc
Au	= gold	Fe	= iron
Ag	= silver	HR	= hot rolled
Cd	= cadmium	CR	= cold rolled

Mg = magnesium

Figure 3-5. Cost per Pound of Some Basic Materials

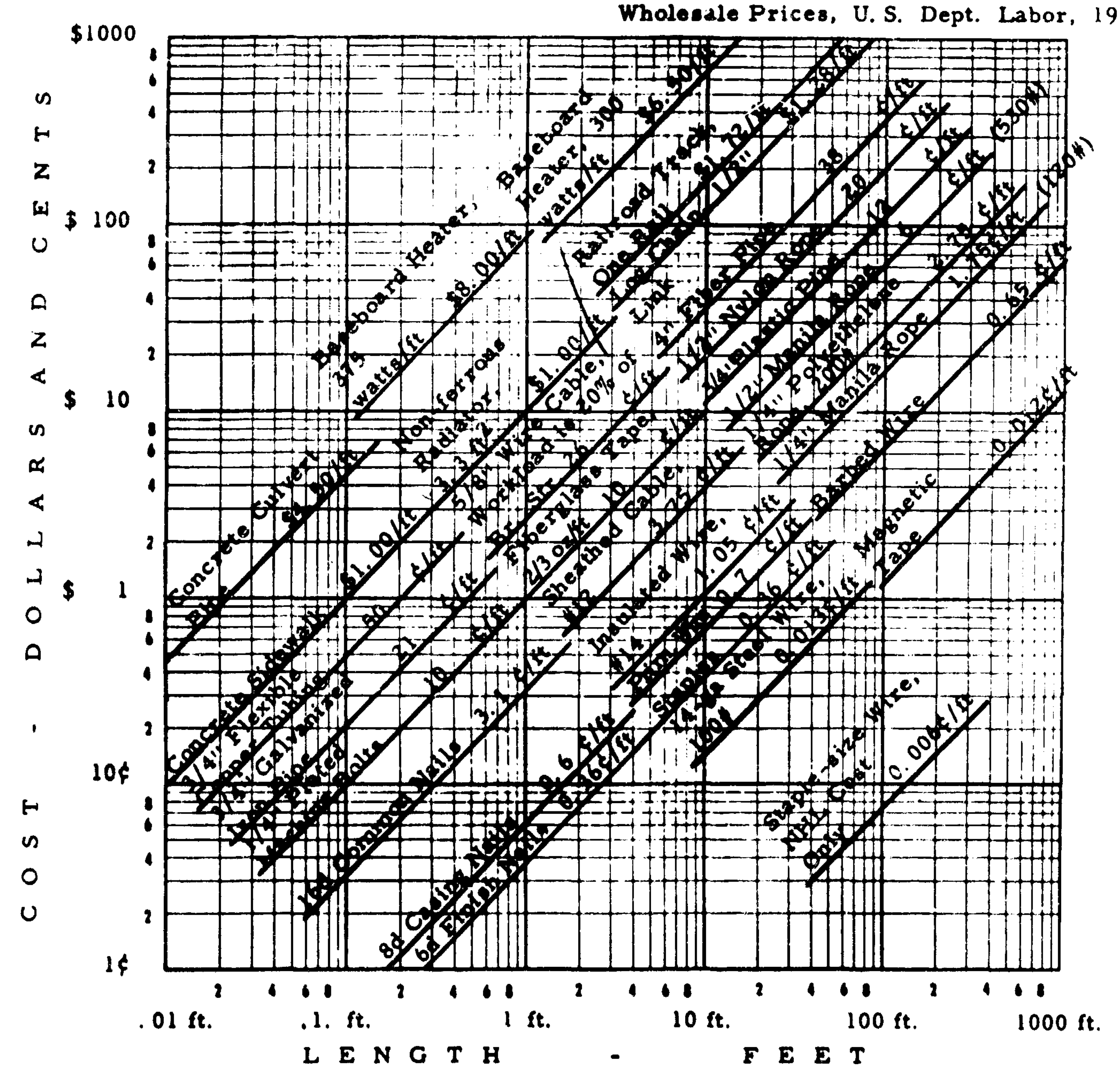
Cost References: U. S. Dept. of Labor
Industrial Catalogs
Commercial Catalogs



in² = square inches
ft² = square feet
yd² = square yard
# = pound

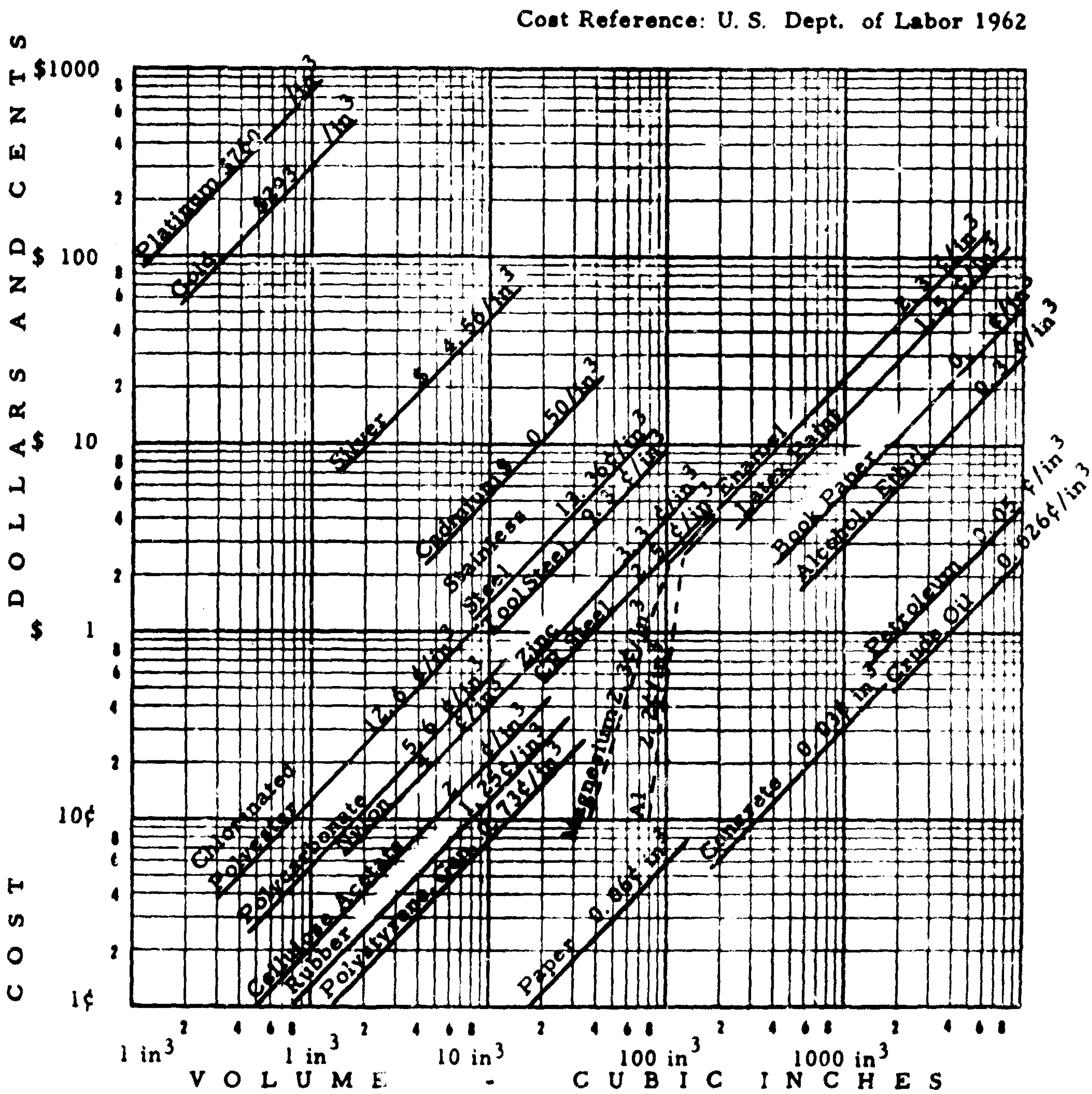
Figure 3-6. Cost per Unit Area of Some Materials

Cost References: Retail Catalogs, 1962 (Sears, Wards)
Wholesale Prices, U. S. Dept. Labor, 1962



= pound or number
" - inch

Figure 3-7. Cost per Unit Length of Some Common Items



in - inch
in³ - cubic inches

Figure 3-8. Cost per Unit Volume of Some Solid Materials

applied to electronic black boxes, missiles, and other items which can be characterized by their internal capacity or volume.

Cost of Surface Finishes. Figure 3-9 is representative of a family of charts that show a functional relationship between costs and surface finishes. Similar graphs may be prepared to relate cost to tolerances, curve radii, and families of fabrication processes such as the different types of castings. The use of absolute cost values for the abscissa will provide more dramatic visibility than will relative cost. Absolute costs will, of course, vary from organization to organization. The cost effect of tolerances, finish specifications and processes may then be used in trade-off decisions.

Breakeven Analysis.

A cost analysis of alternative designs can determine the fabrication quantity point at which one proposed design becomes less costly than the existing design. In many instances, the breakeven point identification is as important as total cost knowledge. It is used to compute the cost consequences of variations in the point in production at which changes are implemented, and hence, the schedule considerations for change proposal processing.

In commercial enterprises, marketing data is usually a pre-determined fact of the study. As such, quantity becomes the basis for several factors--capital facilities, tooling, etc. Defense inventory item quantity varies between contracts, services and annual procurements. This variation affects the method of production, the design configuration and other elements which must be considered in a value study.

Determination. Table 3-1 illustrates one method of determining a breakeven quantity between design alternates. Recurring cost[1] and non-recurring costs[2] are added for each total quantity considered. This total divided by the quantity gives an average unit cost for that lot. This example shows that the design B becomes less costly than design A at approximately the

1. Recurring costs - costs which repeat themselves for each item produced, e.g., material, labor and burden.

2. Non-recurring costs - costs which do not re-occur with each item produced but rather once for each lot, e.g., tooling, design engineering, and qualification testing.

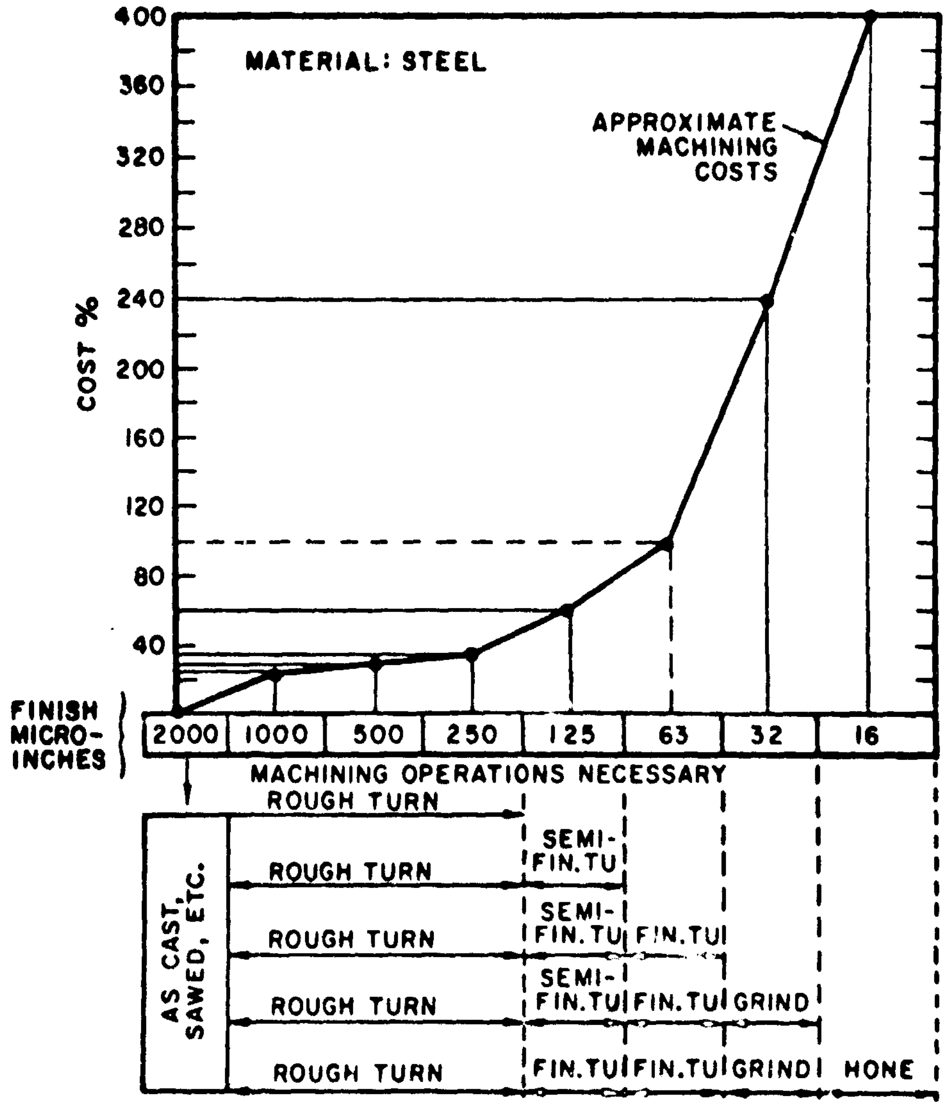


Figure 3-9. Effects of Finish on Relative Machine Cost

26th unit. The learning curve effect on recurring costs has been included in this illustration. An 80 percent learning curve was determined to be typical for these parts.

Table 3-1. Breakeven Quality Determination

	DESIGN APPROACH A			DESIGN APPROACH B		
Quan-tity	Non-Recur-ring Costs	Recur-* ring Costs	Average Unit Cost	Non-Recur-ring Costs	Recur-* ring Costs	Average Unit Cost
1	$1300	$60.00	$1360.00	$1700	$15.00	$1715.00
10	130	28.50	158.50	170	7.05	177.05
25	52	21.00	73.00	68	5.25	73.25
50	26	16.80	42.80	34	4.20	38.20
80	16	14.40	30.40	21	3.60	24.60
100	13	13.20	26.20	17	3.30	20.30

*Breakeven quantity approximately 26 units based upon an 80% learning curve.

<u>The Breakeven Curve.</u> The breakeven quantity represents the point of economical equivalence of alternatives. The determination of the cost relationship of many alternatives may be facilitated by plotting the data on graph paper. The resultant breakeven curve will also illustrate the cost differential at any given product quantity by its slope. Log-log scale paper is used when learning plays a major part in unit cost. An example of such a curve, using the data of Table 3-1, is shown in Figure 3-10.

<u>Change Costs.</u> The analysis of existing design modifications must consider the cost effects of design change.

These factors vary with design maturity and the program stage. A value engineering study that proposes such changes loses validity unless these costs have been considered. Some change cost factors are:

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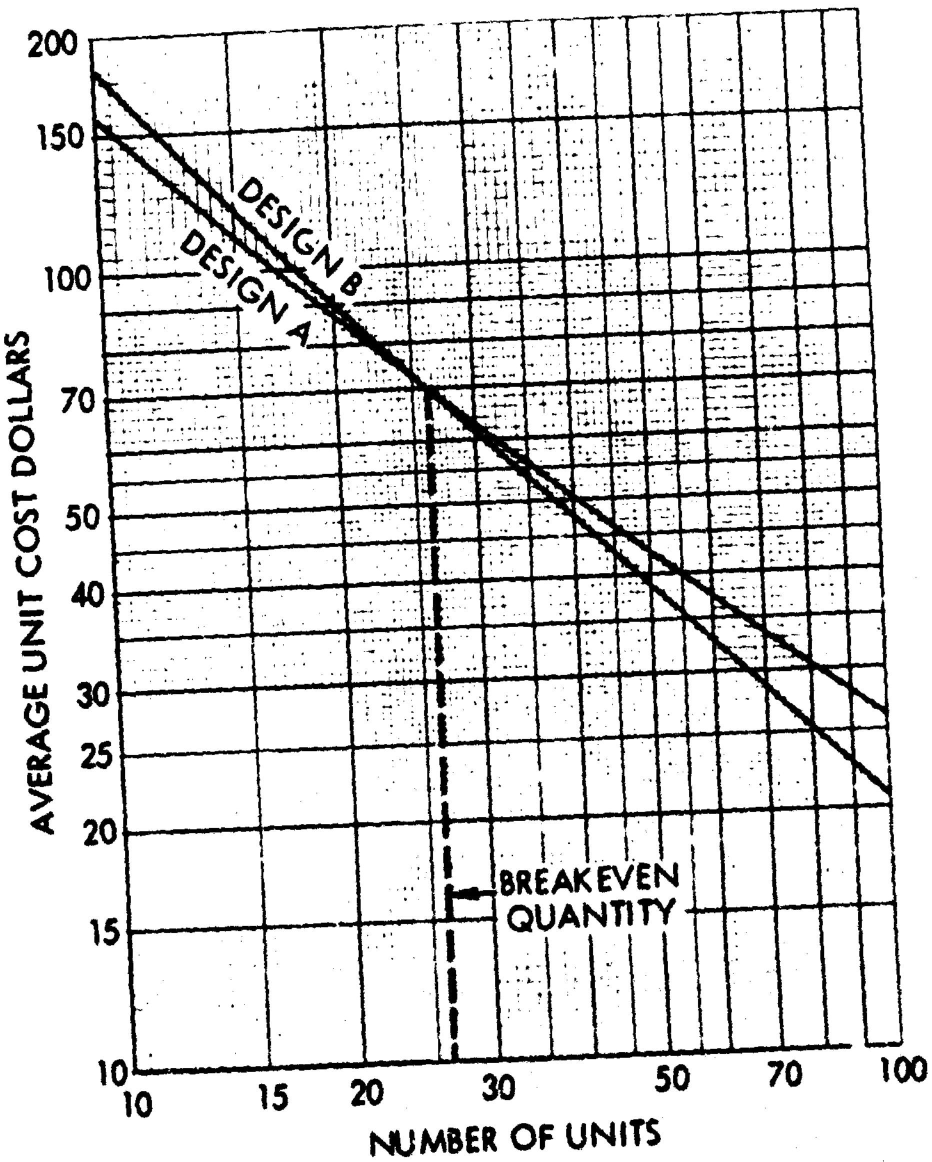

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Figure 3-10. Breakeven Curve

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a) Tooling changes.

b) New facilities.

c) Rework of existing hardware in process and in stock.

d) Modification kits.

e) Re-qualification tests.

f) Data and documentation change costs (handbooks, manuals, drawings).

g) Program rescheduling.

h) Installation costs.

i) Logistics costs.

j) Credit for scrap sale or other disposition of on-hand material that will not be used.

Department of Defense agencies may need to make some of these data available to industry for use in change cost analysis.

COST MODELS

A cost model is a presentation of a value engineering study project arranged to illustrate its major cost elements and their contributions to total cost. It provides: a) increased visibility of the cost elements, b) criteria for establishing cost targets, c) aid in identifying the project's subelements most suitable and fertile for cost reduction attention, and d) criteria for comparison of alternative approaches.

The models may be built in the form of an algebraic equation or as a graphic presentation similar to an organization chart. Complex projects with many cost elements may be more easily handled as equations. A computer may facilitate the solution of complex cost equations when many choices with complex cost equations must be dealt with. Projects with up to 40 or 50 cost elements may be more readily visualized in a "tree chart" format.

Selection of Model Elements.

It is necessary to select the cost contributing elements which will be included in the model. Every cost element need not be included. Judgment must be exercised so that the model will adequately represent the actual

case without being cluttered with the fine details of the actual case that exert a negligible effect. This is the definition and purpose of any model.

Cost Elements. Cost elements are the unit building blocks of the cost model. When presented in the ratios that indicate the quantity per next assembly, or per top assembly, or per contract, they constitute the cost model. The cost elements which are included in the cost model should not be items which the value study can not directly control. For example, overhead rates, G&A charges, and administrative costs are usually not directly reducible by an individual study. Other criteria which may exclude cost elements from the model are: a) they represent a negligible or undefinable portion of the expected or proposed cost of the end item, and b) the dollars they represent are already spent.

Care should be exercised to assure that cost elements are assigned to the proper hardware indenture. For example, if a handbook or manual is associated with the item being modeled, the cost elements for the document should be assigned to the indenture level of the equipment unit that it describes. It may be desirable to prepare a separate cost model for the manual and to then apportion it among the lower indenture items. This would be done if the main contributors to the cost of the manual were a few of the lower indenture items.

Model Structure.

As previously noted, a cost model is an expression of the cost factors which cumulatively express the significant cost portions of an item. For value engineering application, cost models usually present the fabrication portions of end item cost that can be altered by decisions not yet made. The cost model may be structured to represent any one of several choices of the item cost: a) total contract quantity, b) average unit cost, or c) the unit cost of the nth fabrication item. The quantity involved and convenience in handling the data from past experience will usually indicate the best choice.

For example, a relatively low unit cost item which is used in very large quantity on a particular procurement would lend itself to presentation as total quantity cost. The model might contain cost elements summed up for the first unit cost, multiplied by a learning curve factor, plus a single tooling, tool proofing and tool maintenance cost. A high unit cost item

might be more conveniently treated if each cost element is presented in terms of average unit cost. In this case, the summation of total recurring costs (fabrication, inspection, testing, etc.) and nonrecurring costs (tooling, manuals, test equipment fabrication, etc.) would be divided by the contract quantity.

The method chosen should be clearly stated and should result in a meaningful number when dollar figures are assigned to the cost elements. A model which presents unit parts cost as a few cents, or even a few dollars, receives little attention. The model improves cost visibility when the cost of the total quantity is also presented. This is especially so if the total quantity cost of relatively low unit cost items approaches the order of tens of thousands of dollars.

<u>Preparation.</u>

The preparation of a cost model as an element of value engineering cost visibility will be illustrated by an example. As previously noted, latitude exists in the selection of the cost elements and in the method of expressing and combining them. These decisions are based upon the following factors:

A. Model use

   1) selection of projects.

   2) performance of value assurance or value improvement studies.

   3) basis for cost target preparation.

B. Personnel who will use the model.

C. Procurment status or situation.

D. Type of cost data available.

E. Extent to which the hardware or software item is defined.

F. Item complexity.

G. Total dollars involved.

Cost Model Example. A Receiver Module, part number 803-425520, has been selected for value improvement study. It is a cube shaped part about 1.5 inches on a side and contains 111 miniature electronic components and four stamped supporting wafers. Prototypes were prepared in limited quantity but some redesign is anticipated for the present acquisition of 500. Special semiautomatic test equipment is contemplated to check out the integrity of the internal welded joints and portions of the electronic performance. Figure 3-11 shows the Receiver Module and the special test equipment (STE). Ten assembly tooling fixtures will be built which are almost identical to the prototype tooling.

The program plan and budget indicated that four cost elements made up the significant portion of the total cost:

a) Fabrication of 500 modules from outside purchased parts.

b) Inspection of the 500 modules.

c) Design, fabrication and proofing of two sets of special test equipment.

d) Fabrication of ten identical tooling fixtures.

Costs were available for the total procurement. It was decided that the model would be expressed unburdened, that is, as direct costs.

The cost expression for the total contract quantity is written as:

$$C_M = C_{MI} + C_{MF} + C_{ME} + C_{MT} \qquad (3\text{-}1)$$

where:

C_M = total estimated cost of 500 receiver modules and the associated auxiliary items of significant cost.

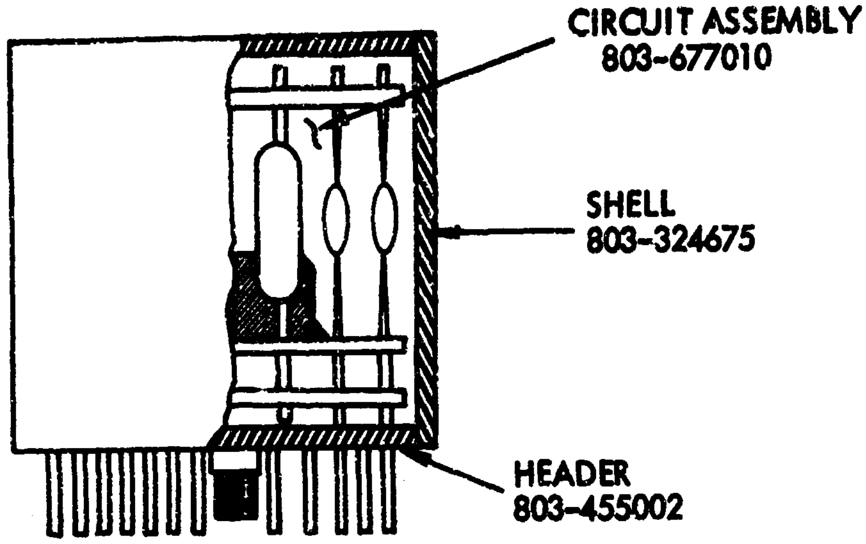
C_{MI} = cost of inspecting 500 modules.

C_{MF} = cost of fabricating 500 modules from their purchased parts.

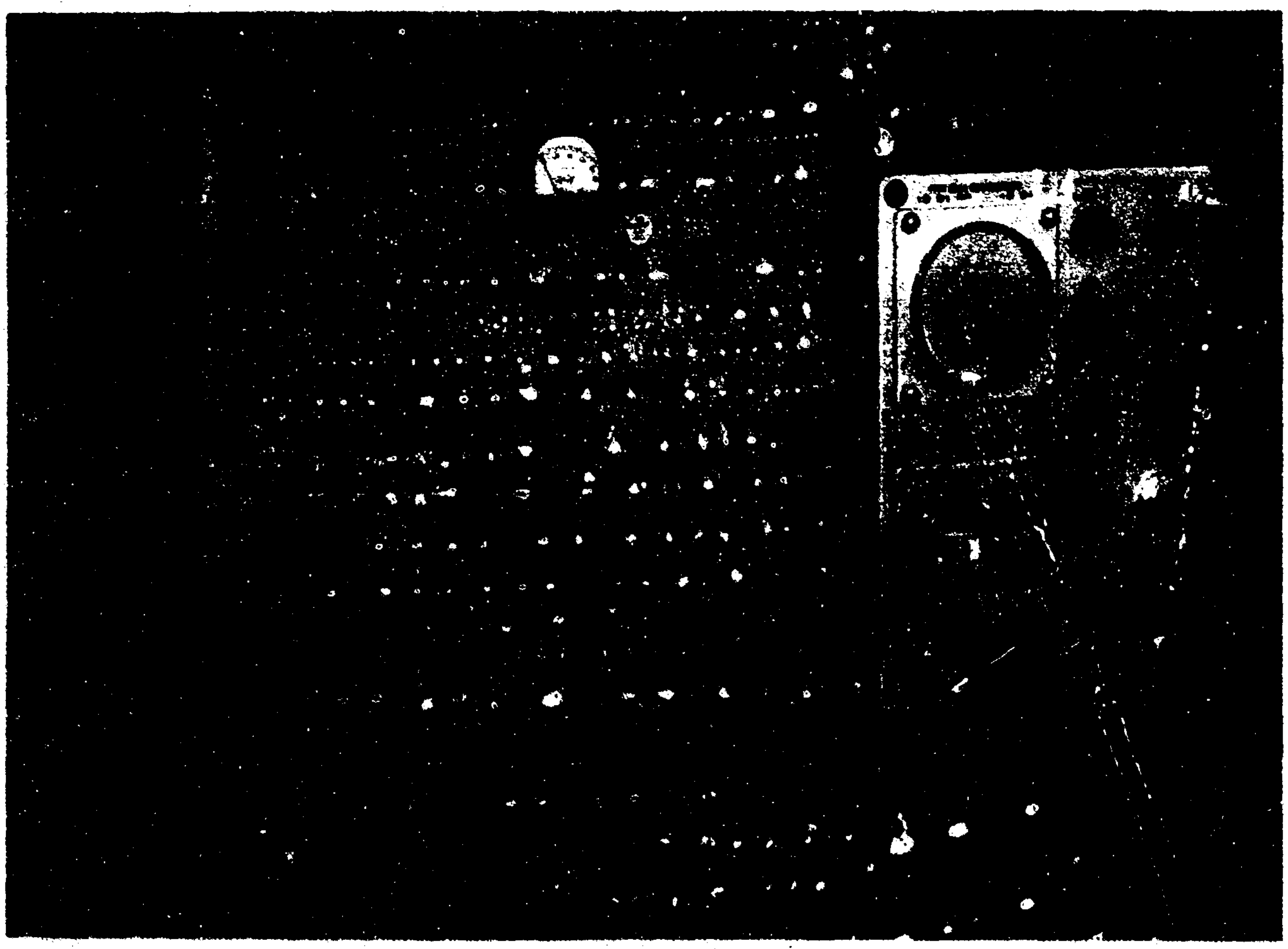
C_{ME} = cost of designing, building and proofing two sets of special test equipment.

C_{MT} = cost of building and maintaining ten tooling fixtures.

C_{MI}, C_{ME}, and C_{MT} were obtained directly from the procurement cost data.



RECEIVER MODULE
803-425520



SPECIAL TEST EQUIPMENT
STE 803-10042

Figure 3-11. Receiver Module and Special Test Equipment

The fabrication of the modules is expressed in terms of its lower indenture cost elements. A total quantity basis was chosen again due to cost data availability in that form.

$$C_{MF} = C_{FA} + C_{FH} + C_{FC} + C_{FS} \tag{3-2}$$

where:

C_{FA} = cost of assembling 500 modules

C_{FH} = purchased cost of 500 Headers, part number 803-455002.

C_{FC} = cost of 500 Circuit Assemblies, part number 803-677010.

C_{FS} = purchased cost of 500 Shells, part number 803-324675.

C_{FH}, C_{FS} and C_{FA} were obtained from the procurement cost data. The cost of the Circuit Assembly was found to be made up of the following costs:

$$C_{FC} = C_{CA} + C_{CI} + C_{CR} + C_{CT} + C_{CD} + C_{CP} \tag{3-3}$$

where:

C_{CA} = cost of assembling 500 Circuit Assemblies.

C_{CI} = cost of inspecting 500 Circuit Assemblies.

C_{CR} = purchased cost of 10,500 resistors (21 per circuit x 500 circuits per contract).

C_{CT} = cost of 31,000 transistors.

C_{CD} = cost of 14,000 diodes.

C_{CP} = cost of 2,000 detail parts (of four types)

C_{CR}, C_{CT}, C_{CD} and C_{CP} were obtained from the procurement cost data. C_{CA} and C_{CI} were obtained from the manufacturing and inspection planning sheets as average unit cost and subsequently modified by the estimating group to reflect learning.

$$C_{CA} = 500c_{ca} \tag{3-4}$$

$$C_{CI} = 500c_{ci} \tag{3-5}$$

(All unit costs are expressed in lower case letters; total quantity costs are in upper case.)

The total quantity cost of the Circuit Assembly was then calculated by equation 3-3.

A similar procedure for the special test equipment was followed. The algebraic expressions for its cost model are:

$$C_{ME} = c_{ed} + 2(c_{cf} + c_{cp}) \tag{3-6}$$

where

$c_{ed} = C_{ED}$ = cost to design STE

c_{cf} = cost to build each STE

c_{cp} = cost to proof each STE

Equation 3-6 was developed in terms of unit costs since it was found that that was how the estimates were developed in order to cover options of 1, 2 or 3 sets. Two sets had been selected and no significant learning differences were expected.

The remaining unit costs were developed by dividing total cost by the appropriate quantity. The resultant model shown in Figure 3-12 demonstrates the contribution of the unit cost of each item in the proper context of its contribution to total cost.

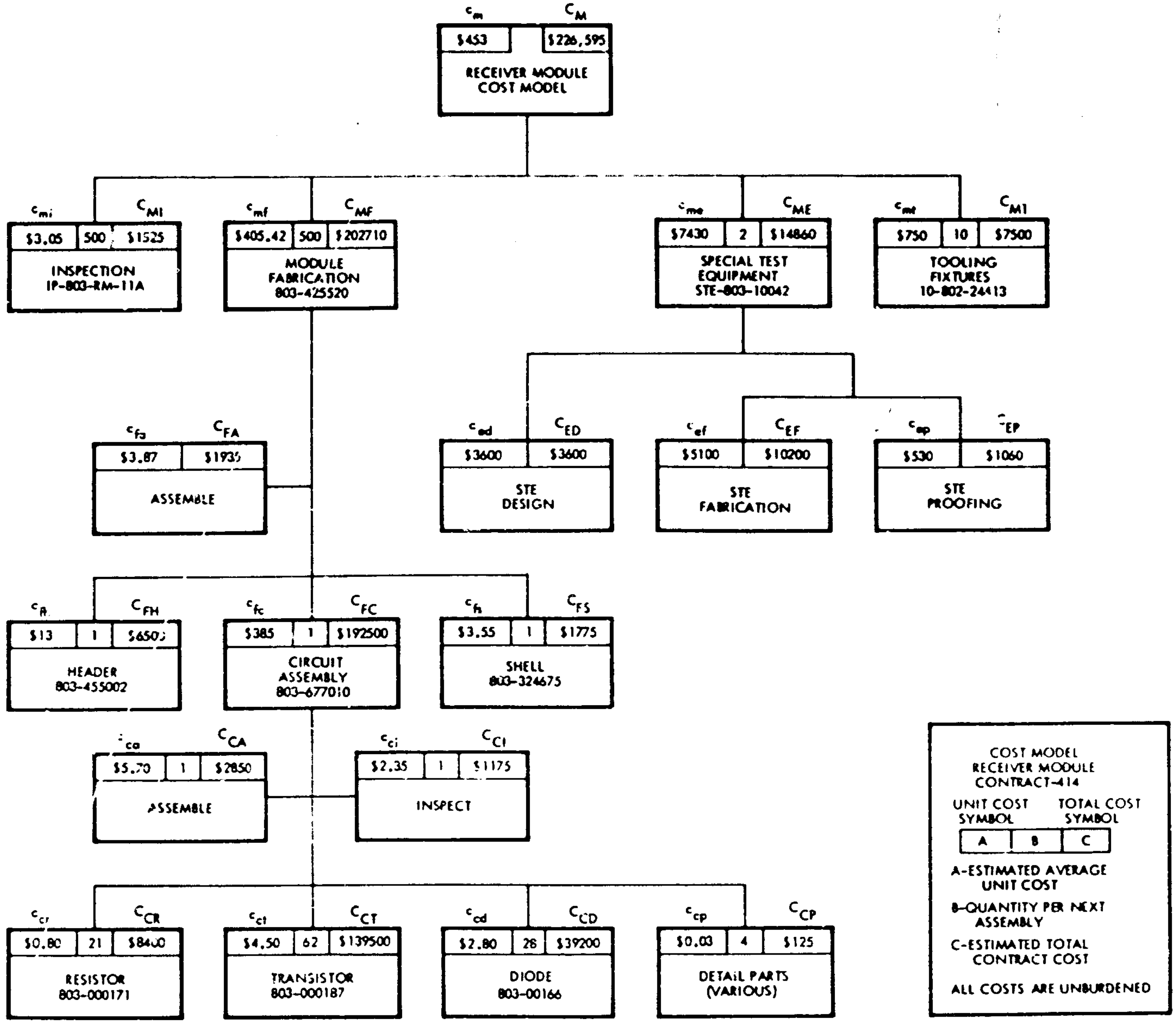


Figure 3-12 Receiver Module Cost Model

COST VISIBILITY: SUMMARY

A. The price of defense inventory items is based upon estimates of time and material to be used directly for the item, plus a multiple of the estimates which provides for labor and material of allocable burden support, plus a multiple of the direct and burden for general and administrative costs, plus profit or fee.

B. The nature of the pricing process tends to magnify any deficiencies in the estimated cost.

C. The accuracy of an estimate is influenced favorably by maximum capability and experience of the estimating personnel and unfavorably by the lack of design maturity and adequate time to make the estimate.

D. The learning curve is a useful method of rapidly estimating the amount that the cost of an item diminishes as production proceeds when unchanged, and the fabrication cost perturbations that result from changes.

E. Cost analysis, formulae, and charts which express cost per characteristic unit and cost ratios for various design factors, provide a means of assessing cost reasonableness.

F. Choices between alternative designs and changes to designs need identification of the breakeven quantity, the point when the total average unit cost of one design becomes equal to the cost of another design.

G. Cost analyses of alternate designs must consider the cost factors which are involved in carrying out the change process, such as new tooling, facilities, testing, and documentation.

H. A cost model of a subject under value study facilitates consideration of the cost elements which make the major contribution to total cost.

I. The cost model should include hardware and software elements directly associated with the project.

J. Cost models should present unit costs, quantity involved and total costs projected to reflect future expenditures.

Chapter 4: Program Elements

A value engineering program consists of separate tasks appropriate to its application. . . this Chapter describes seven of the most likely individual elements for use in DoD and Industry value programs. . . The mechanics of performance. . . application. . . personnel. . . inputs and outputs are presented for Value Training. . . Value Studies. . . Task Forces. . . Cost Targets. . . Value Reviews of Designs and Specifications. . . Materiel Value Program. . . and Project Requirements Assessment.

CHAPTER 4

PROGRAM ELEMENTS

The value engineering theory may be utilized in various formats as needed by the using agency of the project to which it is applied. Specific tasks which have a direct bearing on the achievement of an organization's overall value engineering objective will be called the program elements. They are separate and identifiable portions of the total task of achieving best value in defense products. Selectively combined they satisfy DoD program requirements for value engineering.

This Chapter describes most of the program elements in use today. The choice for specific applications will depend upon the magnitude, acquisition phase and type of items involved. This Chapter will provide the details of performance that will enable one to make the appropriate choices. Each of the elements can be described, manloaded, scheduled, and assessed. Selection from the program elements in this Chapter will also provide a base for incorporating value engineering in contract work statements. Additional program elements may be developed for special requirements and as the state of the art advances.

All of the task elements involve participation by value engineering personnel in their establishment or in their performance. However, primary responsibility for several of them may reside with other functional areas of the organization with support assistance from the value engineering group. Satisfactory accomplishment in these cases may depend upon the availability of value trained personnel.

VALUE TRAINING

The accomplishment of cost avoidance during the design and development phases of a product's life cycle rests primarily with the personnel directly involved with creating that product. Training in definite methods and disciplines of value engineering will improve their capabilities to operate on cost stimuli, at the same time imparting a value climate of proper balance between technical and economic considerations. Value training is equally important in other phases of a product's life. Operating personnel with responsibilities for reducing existing product costs need to acquire skills in the value engineering techniques. Training is the basic element of a value program at this time.

The value engineering skills and techniques are presently either nonexistent or rare in the undergraduate curricula of colleges and universities. Until they become available and personnel come to industry and the DoD with this education in their background, it will be necessary to provide "in-house" instruction.

Trainee Selection.

To maximize the accomplishment of value engineering in all organizational elements, training exercises should include attendees drawn from the various line and staff functional groups which have value responsibilities. This attendee "mix" will vary and should be periodically reviewed to assure that trained personnel are located within each major functional area. The interface between the DoD and its contractors may be improved through value training programs. When representatives of subcontractors, contractors and government agencies participate together in training programs, additional communication benefits develop.

Types.

Value training programs may be classified as two major types - orientation and workshop. Both types are essential to a well operated value training effort.

Value Orientation. This type of training includes familiarization sessions which range from one to eight hours. They are designed to acquaint attendees with value engineering fundamentals, goals, and general operating methods. These sessions are especially appropriate for personnel whose

primary responsibility would not require attendance at a full-scale workshop seminar. Upper-level managers, senior staff personnel, field operations, draftsmen, and laboratory technicians are examples of individuals who would attend this type of training.

The content, length, emphasis and format of the presentations included in these orientations must be matched to the particular audience. Certain basic features, however, are common:

a) Principles of value engineering theory
b) Examples and case histories
c) The structure and operation of the value engineering program
d) Contractual aspects
e) Responsibilities of the audience towards the value program

Workshop Training. A workshop or workshop seminar, is an intensive training exercise commonly of 40 to 80 hours over 2 to 4 weeks. It's content includes lectures in techniques and methodology and combines this instruction with team project work. It provides the opportunity for application of the theory in a controlled environment. Value engineering effectiveness is demonstrated by project work participation, personnel communications are improved by exposure to new contacts, actual cost improvement proposals are generated by the project exercises, and personnel with special capabilities and interest in value work are identified.

Facilities. Adequate facilities are an important consideration for workshop seminars and orientation sessions. Presentations should be made in a lecture-type room with comfortable seating, good lighting, ventilation, and low noise level. Workshop seminars need thirty to forty square feet per attendee of total floor space for tables, seating, displays, and reference materials.

Curriculum. The curriculum for value engineering training should be especially structured to fit the areas of application that the participants are most likely to find for the techniques that they learn. For example, the training aids and some lecture material appropriate to personnel engaged in fuse development would be inappropriate to personnel normally engaged in aircraft maintenance. Project office personnel who extensively interface with industry need more material on contractual aspects and industrial cost estimating than research laboratory people. It must be

planned in advance and staffed with capable instructors and guest lecturers for specialty subjects. Lectures should provide a combination of:

a) Basic instructional and background material.

b) Enthusiasm and interest-generating motivation.

c) Variety of presentation, e.g., a number of different speakers.

d) Variety in program -- lectures, audience participation, films, discussion, exhibits, project work, etc.

Personnel. Three types of personnel, other than the attendees, are usually involved in a value engineering seminar: a) lecturers, b) guest speakers, and c) project leaders. The lecturers, from two to five, provide the direct discourse on value engineering principles and allied matter such as creative problem solving. Guest speakers may be used to cover the specialty areas of in-house disciplines which touch on value considerations. These may include contracts, finance, technical specialties, logistics, price analysis, and etc. Project leaders work with from one to three teams to provide guidance and stimulation during the project work portion of the seminar.

The lecturers must combine an understanding of their topic with the ability to communicate. Their function is primarily to educate. They do not all need to be value engineering personnel, but it is desirable that they have previously attended a seminar. Guest speakers should be experts in their field. Familiarity with value engineering and lecture capability are necessary. Project leaders must have previous value engineering experience. They should be able to keep the team energized. Members of a value engineering group usually perform well as project leaders.

Priority of Attendance. Conflicts between the pressures of normal work assignments and seminar attendance should be resolved prior to the selection of participants. Administrative directives and personal contact with attendees and their supervisors are suggested to resolve problems in this area. Regular attendance at workshop seminars is important for the trainee.

Timing. Workshop seminars may range from 40 to 80 hours. In some cases half-day sessions have been found to be desirable. In this manner normal job continuity may be maintained over the seminar period.

Less than half-day sessions are inadequate, and less than two weeks for the seminar makes it difficult to obtain vendor quotations. In any event, the total calendar time between the first and last sessions should range from two to four weeks.

Attendees. The optimum class size will vary according to the organizational needs and availability of experienced team project leaders, but should not exceed fifty. The larger groups require very careful planning of project work and vendor coordination to assure adequate coverage for all teams. Attendees for each seminar should be drawn from line and staff functional groups, including engineering, procurement, manufacturing, finance, quality, project offices and others whose job performance has a significant effect upon product cost.

Project Work. The material included in Chapter 5 of this Guide provides details for this portion of the workshop seminar.

Vendor Participation. To acquaint participants with the suppliers' role, a limited number of vendors (from five to fifteen) may be invited to participate in the seminar. An appropriate format is to invite the vendors to send two representatives, one technical and one cost estimating type, with a small display of their product or process. Vendors should be selected which are appropriate to the workshop projects. A portion of the project time should be set aside for the team members to discuss their projects with the vendors in attendance.

Value Personnel Training.

Basic training for value engineering personnel is the workshop seminar. It provides an excellent opportunity for him to demonstrate if he has an inherent interest in and talent for value work. It needs to be complemented by further training and experience in his specific area of application and related disciplines before the individual is fully effective. Designation as a value engineer should be predicated upon an academic degree or the equivalent in years of experience in related fields. With that as a baseline, further development should include demonstrated aptitude in a workshop seminar, proficiency during a period of on-the-job training, and attendance at one or more related courses. A number of universities have suitable specialized courses and offer certificate programs for the professional designee.

Training Responsibility

The administration and operation of a value engineering training program is normally a joint responsibility of the value engineering group and the training group. The distribution of this responsibility will depend upon the workload, major tasks and manpower availability. Regardless of the exact distribution, it is important for both groups to be involved so that each will provide its specialized talents. In organizations with no training group, the entire effort will be within the value engineering function.

Typical responsibilities for value training are:

Value Engineering Responsibility. The value engineering group will:

a) Formulate the technical aspects of the curriculum.

b) Provide appropriate speakers and related visual aids material.

c) Provide team projects, project leaders, and necessary supporting data.

d) Provide technical support.

e) Follow-up project work for possible implementation.

f) Assess the effectiveness of the training in the organization's value engineering program.

Training Responsibility. The training organization will:

a) handle arrangements for facilities, equipment, and services,

b) conduct the seminars,

c) measure the effectiveness of the activity and provide feedback data to value engineering,

d) assist in the selection of participants.

VALUE STUDIES

The value study is the basic operating mechanism of value engineering personnel. It entails the performance of value assurance or value improvement efforts on specific projects. The projects may be selected as a portion of this task or they may have been identified by other task elements such as training, cost target programs and value reviews. Value studies are usually done by an individual who follows the process already described

by the Job Plan. He obtains information and special assistance from personnel in other areas of the organization as needed.

Procedure.

The value studies task involves five steps: a) project selection or verification of projects identified by other activities, b) making the study, c) reporting of recommendations, d) implementation assistance, and e) results verification. All of these have been previously discussed in detail. The input to this task is likely projects from which choices are made and the output is a report of recommendations. By-product outputs may be summary reports of resultant action by the personnel responsible for implementation and verification of achieved cost reductions or cost avoidances.

Application. This task is suitable for application to hardware and software items for almost all areas of DoD usage. The main criterion for applicability is the existence of potential for cost reduction. The performance of value studies requires the full time availability of at least one value engineering personnel. Each step of the Job Plan generates periods of relative inactivity while waiting for cost estimates, quotations and technical verification analyses; consequently, one value engineer can perform several studies simultaneously. Value studies will usually require from four to ten weeks from start of the Job Plan to issuance of the study report. Implementation timing and action are dependent upon the personnel responsible for and with the authority to take action on the study recommendations. However, the value studies schedule should make provision for time to follow-up each report.

TASK FORCES

Description.

The task force is a mechanism for applying value engineering in the workshop training seminar and in practice. Personnel are designated to deal with an assigned value problem, usually within a definite length of time. It represents a formal team approach to the study of a specific item as opposed to performance by an individual who informally obtains special help as he feels he needs it.

The group exercises provide:

a) mutual demonstration of the reality of each members' contributions to and effects upon value.

b) a heightened sense of personal stake in the value engineering proposal's final disposition.

c) improved communication among the team members and their work organizations.

Structure.

A value engineering task force is composed of four to seven members. Each member is selected from a different organizational element. Every task force should have representation from: a) production, b) engineering, c) procurement, and d) value engineering. Additional personnel are chosen from other disciplines that are significant determinants of the project's value.

The nature of the project (hardware or software; electronic, chemical, motor oil or clothing) will guide the selection of team members. At least one of the task force members should be competent in the project's major technical specialty. All, or at least most, should have had value training. Task forces may include the originator of the project, especially if it is his opinion that the article can be improved.

Operation.

The use of task forces as an element of a value engineering program should be supported by in-house documentation which describes how the following operations will be managed.

Formation and Disbanding. The individual in authority whose approval will be required to create a task force is significant to the actual operation of the value engineering program. The initiating authority needs to be at a level that can make personnel assignments from the various organizational units that will be represented on the task force. Although the authority for the day to day operation of the task force will normally be delegated to the head of the value engineering organization, the initiating authority should be the one that disbands the group.

Inputs. A task force should be provided with:

a) Name and organization of the members.
b) Particular project as their assignment.
c) Background of the projects selection.
d) Schedule for completion.
e) Designation of the task force leader.
f) First task force meeting date, time and place.
g) A definite goal.

At the first session the team should be given the documentation and samples pertinent to their assignment. In actual practice, the teams may be expected to do more information gathering than in the training mode. Value engineering personnel normally do the pre-meeting preparations.

Performance. The task force follows the Job Plan and performs a value engineering study. As previously discussed, each member need not separately perform every step of the study. Hence, the task force need meet in group session only for those elements of the Job Plan which require team effort. As a minimum requirement, regular weekly meetings of the entire team for one or two hours should be held during the task force life.

The value engineering member has the following responsibilities during a task force study:

a) Serve as the team specialist on the project's value aspects.
b) If not acting as chairman, serve as the task force secretary.
c) Coordinate the preparation of the study report.

Output. The visible result of a value engineering task force is a report of its recommendations. The report should be structured as described in the Job Plan discussion of Chapter 2. Some intangible benefits accrue from the cooperative team effort which are not directly assessable. The task force is normally disbanded after its report is accepted by the initiating authority.

Post Task Force Activity. The value engineering personnel are responsible for following the team recommendations to implementation and verification of the final disposition. This effort is similar to the final phase of the Job Plan.

Application. The use of task forces would be suitable as an element of a value assurance or value improvement program. Its application normally occurs after a project has been identified and selected by any of the methods noted in Chapter 1. Task forces tend to make more efficient use of the value engineering personnel. One value engineer should be able to serve about three simultaneous team studies. The creation and successful operation of task forces depends upon the resources of value trained personnel in the operating elements from which team members are drawn.

COST TARGETS

A cost target program is a method of using predicted cost data to obtain positive consideration of fabrication (or acquisition) cost during the design phase. A cost target is a feasible dollar amount preset as a desired goal for specified elements of an item's fabrication cost. It is not the item's total cost and it is not a contractual or negotiable number. Cost targets for individual hardware items should not be confused with the target cost of incentive contracts.

Cost target program operation identifies the individual items of hardware that need value study at one or more points prior to their release for production. The program structure should provide for this isolation to serve as input and stimuli for corrective action by engineering, value engineering, task forces or other responsible elements of the value program.

Application.

The following situations are a guide to selecting applications for cost target programs. In all cases economics must be examined as the final test:

a) R&D programs which contain fabrication of sufficient hardware dollar volume to justify the application.

b) Production procurements or re-procurements of previously designed items when time is available or will be devoted to their improvement prior to fabrication.

c) Production programs of sufficient time duration to permit study and redesign and timely implementation.

Cost target efforts are normally applied to the hardware. They provide coverage for those documentation items that are closely associated

with the targeted hardware. Although the basic procedure is applicable to software, this Guide will reflect its past major usages on hardware.

The cost target application to a given contract may be only for a portion of its hardware. Some, but not all, of a program's hardware may justify treatement. Partial application will also cost somewhat less than full application, though not at a linear rate. Guidelines for selecting items are provided below.

Procedure.

The operational procedures of a cost target program must be tailored to the using agency or program. However, a broad description can be provided. The procedure is characterized by an iterative feedback of a predicted cost for an end item at several discrete points (for example, design reviews) during the design process. Each feedback provides an under-target, over-target, or on-target signal. Over-target items become the subject of intensive value study (for example, by task forces); under-target items are evaluated for possible reduction of the target. No action is taken for on-target conditions. Final evaluation of the program effectiveness is performed when the verification point, usually a delivery point during fabrication, is reached. At that time, the achieved actual cost of each targeted item is compiled in the same structure as the basic cost model which was used to prepare the cost target.

Selection of Items. Not all programs, or all items on a program, are amenable to cost targeting. The ection should be made as early in the program as possible. Various criteria may be employed in making the decision:

a) The total estimated item production cost is high enough to warrant its share of the cost of the targeting effort.

b) The items represent the lowest level of indenture which is assigned to an individual designer.

c) Development and testing is involved rather than off-the-shelf selection.

d) Recent developments indicate a potential opportunity for cost reduction.

e) Previous experience with a given type of item indicates a pattern for its actual production cost to exceed its porposed cost and (a) above also applies.

f) The assigned designer has had previous difficulty in achieving cost effectiveness.

g) The future use of the item depends upon significant reductions in cost.

h) Cost prediction and accumulation of actual cost are possible.

The levels of indenture at which targets are assigned may depend upon the extent to which the hardware is defined. It may be necessary to target end items progressively down through the indenture levels during the preliminary design phase as the hardware nomenclature is definitised.

Selection of Monitoring Points. Monitoring points are the discrete milestones at which formal comparisons are made between the item's predicted cost and its cost target. These may coincide with one of more of the following: a) design reviews, b) design engineering inspection, c) pre-production release reviews, and d) pilot or prototype completion. They should be selected to achieve a balance between the capability to prepare meaningful predicted cost estimates and the time remaining to make value studies and to take corrective action. The accuracy of predicted cost estimates varies inversely with the time remaining to accomplish cost avoidance. For this reason at least two, and preferably three, successive monitoring points prior to design release should be selected. Those programs which will involve production periods of about a year or more should have a monitoring point early in their production phase. The point of five percent or ten percent production run completion may be appropriate. The law of diminishing marginal returns will help to determine the last feasible date for monitoring. Once monitoring points are established, they should be published as a part of the master program schedule.

Selection of the Verification Point. The verification point is the discrete occurrence for which the cost targets are structured. For example, the cost targets may be set for the cost of the tenth deliverable item or for the average unit production cost. The actual cost is determined as of the occurrence of the verification point. The difference between the achieved cost and the cost target (over, under, or equal) is indicative of the cost effectiveness performance. It could also be reflected in the fee or profit of incentive contracts.

Setting Cost Targets. Cost targets are created by assigning dollar values to each major cost element of the item. The cost elements which are included should be those over which the 'action level' personnel may be logically expected to exert some measure of control. For example, overhead and various administrative cost elements are not directly reducible by the designer and should not be included. Another criterion under which cost elements may be excluded from the model is if they represent a negligible or undefinable portion of the expected or proposed cost of the end item. The cost model process is useful for preparing the cost target structure.

After the elements are selected and the structure is defined, the actual target dollar amounts are set. The targets should be less than the originally estimated cost which was used to compute the contract cost. This provides a cost reduction goal.

There are several possible bases for generating the dollar assignments. They may be some arbitrarily fixed percentage less than the proposed cost. The functional analysis approach of establishing the least cost to perform the required functions may be used. A desired cost, which is related to the price adjustment formula of an incentive contract, could be used. The system selected may be a combination of any of these.

The cost target for the top assembly of a hardware unit of several indentures may be synthesized as the sum of the created subassembly targets created individually for the lowest indenture levels. The converse approach may be used; a cost target is created for the top assembly and is then apportioned downward among the subassemblies. Each subassembly target is then distributed among its detail parts downward through the indenture to the previously selected lowest level for targeting.

Each user must analyze and determine the most effective approach. However, the following criteria must be satisfied for each established cost target:

a) The cost target should be attainable.

b) The responsible action level personnel (designer, production engineer, procurement specialist, etc.) should participate in target establishment.

c) The responsible designer should understand the basis for and the use of his cost target.

Monitoring. The monitoring phase starts after the cost target has been assigned. It consists of predicting the cost for the design under consideration and comparing it with the cost target. The variance between the predicted cost and the cost target is considered at the design review or other formal approval points.

A Target Cost Event Chart may be used to communicate the cost target status for each targeted item. Progress in achieving cost reduction goals can be monitored by these charts. Each responsible individual receives an updated chart for his item at each monitoring point. Figure 4-1 is a Target Cost Event Chart for a typical end item at program completion. It shows the necessity for, and the results of, two task forces (in this case) and the final relationship of the achieved cost to the original target.

VALUE REVIEWS

Value reviews as a program task element includes the efforts which lead to and provide for the formal approval of designs, specifications, or procurements. For example, Design Reviews would become Design Value Reviews upon the incorporation of value engineering as an element of the review and approval process. Design and Specification Value Reviews may be combined. This Guide will discuss value reviews in the design context. However, the methodology is applicable to many other procurement or in-house decision situations.

The value engineering responsibility includes: a) determination of the reviews to be held, b) generation of the procedures for them or, the incorporation of value engineering considerations into existing procedures, c) performance of the value engineering analytical effort preceding the reviews, d) review board representation, and e) the generation of checklists to be used by the design or specification personnel in assuring their consideration of value engineering requirements as preparation for review board evaluation and approval.

Value Design Review.

The purpose of the design review function is to verify that the design approach being taken will best fulfill defense needs. It is an organised, formal effort, implemented at major milestone points during development, guided by the technical standards and the specified requirements. The

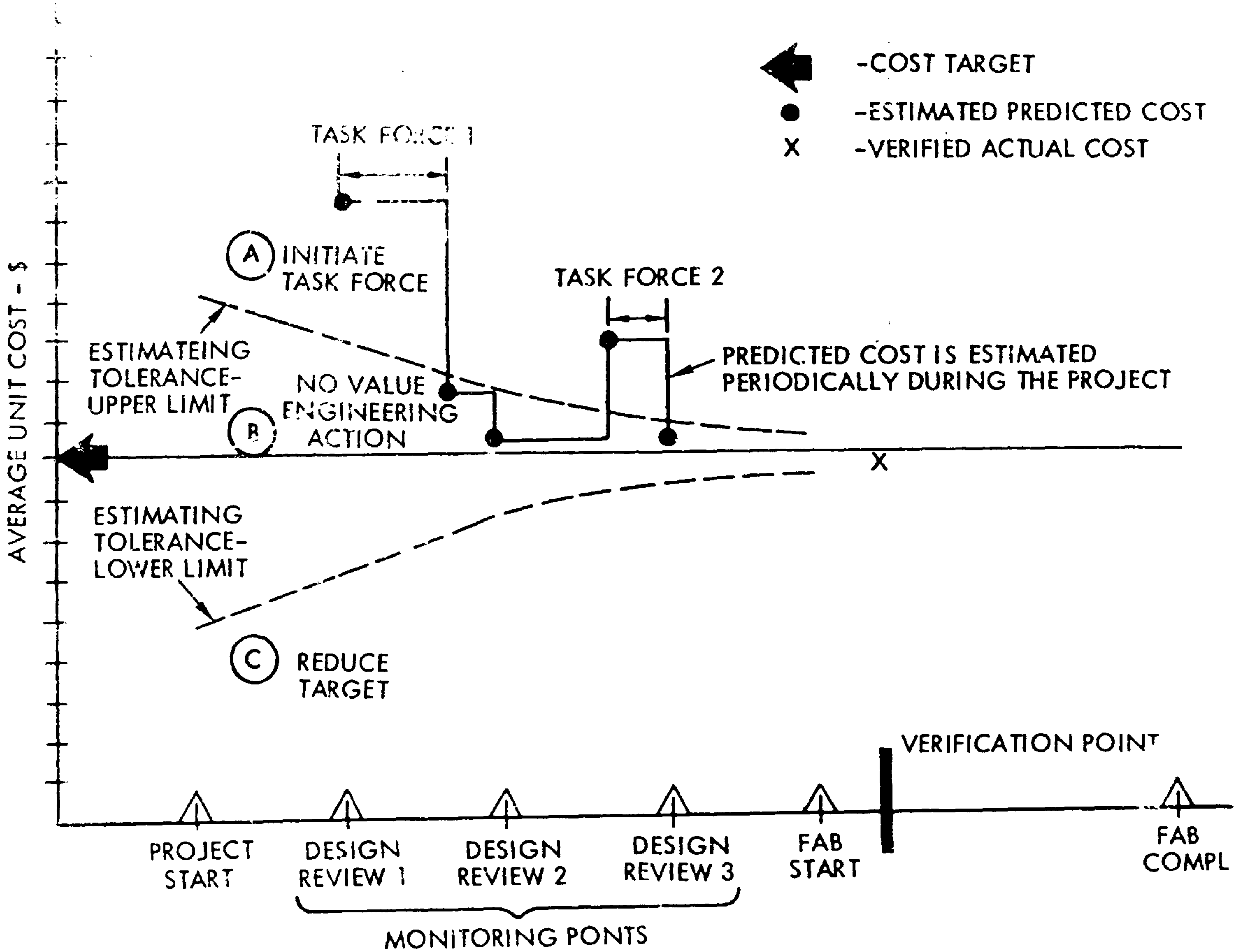


Figure 4-1. Target Cost Event Chart

value design review has provisions which increase the attention presently given to economic aspects.

Application. The design review procedure is normally applied to hardware during the R&D phase. A Design Review task statement or specification may be in existence at the installation or may be found in contracts awarded by the installation. Value design review requirements may be placed in the agency's value engineering program regulation or other description.

Procedure. Specialist personnel individually review the design drawings and other data. This is followed by a joint discussion of identified problems which leads to the assignment of action items for resolution. For maximum effectivity, most of the participating specialists should not have been directly involved with the creation of design under review. For value design reviews, one of the specialists may be a value engineer.

Value design reviews may occur: a) wholly within an industrial contractor or DoD organization, b) as a joint effort of a contractor and the procuring agency, or c) as a joint effort of a contractor and one or more subcontractors.

Economic Considerations. A value design review places special emphasis upon the economic aspects of the design. Some of the cost facets which should be considered during a value design review are:

a) Identification of an initial cost target for each design "package."

b) Comparison of a cost estimate for each design alternative with the cost target.

c) Establishment and discharge of responsibility for cost control.

d) Determination of the prices and price breaks of purchased parts.

e) Solicitation of cost reduction ideas from design review team participants.

f) Functional analysis of the design requirement and the design alternatives.

COST TARGET

Management Directives. Management participation in the design review program is a prerequisite for the development and issuance of effective value design review directives. This support is manifested when:

a) Specific responsibilities are designated for their conduct.

b) Authority is delegated for their conduct, e.g., a Value Design Review Monitor is appointed.

c) Requirements and procedures are established for design data distribution.

d) Value Design Reviews are scheduled in the master program plan.

e) A procedure is set for Value Design Review Committee membership.

f) Post-review responsibilities are assigned.

The directives and procedures are implemented under responsiblity assigned to a Value Design Review Monitor who:

a) Schedules review milestones.
b) Follows up on action items generated at the reviews.
c) Publishes design review status charts.
d) Mediates interdisciplinary differences.
e) Reports on review progress and effectivity.

Timing of Value Design Reviews. The number and timing of value design reviews are a function of design maturity. The nomenclature indicates their place in the schedule. Four may be found necessary and labeled as: a) conceptual, b) technical, c) major and d) final. Some organizations use three, called: a) concept, b) layout, and c) detail. Some call the detail review the package review. The number and timing are determined by the completion of the concept data, the detailed layouts and schematics, and lastly, the completion stages of detail drawings, specifications, test data, etc.

Value Engineering Role. Presence of value engineering personnel on the review team may be specified as an element of the value engineering program. His presence and tasks provide assurance that consideration for cost effectiveness is being given to every element of design. This objective will be accomplished by analyses before the Value Design Reviews and inputs to them.

At the time of the reviews, the value engineer should have a concise summary of up-to-date events and projected goals for the remainder of the program. Specifically this summary should include:

a) Existing and potential problem areas and recommendations for their resolution.

b) Completed and in-process value studies.

c) A functional analysis of the item.

d) A list of high cost areas and specific recommendations for minimizing cost.

e) Cost target data on the item.

f) Predicted cost estimates of the alternative approaches under consideration.

Small programs and installations often cannot justify sufficient value engineers to provide full time coverage of all reviews. The major portion of available time should be spent concentrating on the high cost areas during the conceptual and technical stages.

Design Review Check Lists. A wide variety of value check lists have been made available for use with reviews; their use should be mandatory. Formal use of check lists provides a means of approaching the intent of the Value Design Review at minimum cost. Check lists need to be structured for the particular type of product to which they will be applied. Thus, there might be an Electronics Assembly Value Check List or a Missile Air Frame Value Check List. Additionally, separate check lists may be needed for conceptual and final reviews. The degree of their effectiveness is directly related to the seriousness of consideration which members of the Value Design Review team give to them. This is one reason that the creation of a cost-conscious environment must have personal attention. A brief example of some possible check list elements is given in Table 4-1.

Table 4-1. Typical Value Design Review Check List.

General

1. Have the specifications been critically examined to see whether they ask for more than is needed? Yes___ No___

2. Has the cost of any overdesign been defined for its effect on production as well as on the R&D program? Yes___ No___

3. Has the cost effect of contractually-required overdesign been discussed? Yes___ No___

4. Has the field of commercially available packaged units, subassemblies, and circuits been thoroughly reviewed to be sure that there are no standard vendor items that will do? Yes___ No___

5. Have suggestions been invited from prospective suppliers regarding possible value improvement from loosening specification limitations? Yes___ No___

6. Does the design give the user what he needs and no more? Yes___ No___

7. Could costs be radically reduced by a reduction of performance, reliability/or maintainability? Yes___ No___

<u>Parts Selection and Evaluation</u>

1. Have appropriate standards been consulted for selection of standard components? Yes___ No___

2. Can a redesign omit a nonstandard part or replace it with a standard part? Yes___ No___

3. Have all nonstandard parts been identified and approved? Yes___ No___

4. Has the design been coordinated with similar designs, circuits, parts or components to benefit from past experience? Yes___ No___

5. Are the standard circuits, standard components and standard hardware the lowest cost standards which will supply the minimum required characteristics? Yes___ No___

6. Can the use of each nonstandard part of circuit be adequately justified? Yes___ No___

7. Can any new nonstandard part be replaced by a nonstandard part which has already been approved? Yes___ No___

8. Do control drawings leave no question that a vendor standard part is being specified when such is intended? Yes___ No___

9. Has standardization been carried too far so the cost of excess function is greater than the gains resulting from high quantity? Yes___ No___

______________________________ Responsible Designer   ____________ Date

Integration with Cost Targets. If the value engineering program includes a cost target program, this program should be integrated with the Value Design Review activity. The cost target that has been developed as a design requirement is compared with the estimated costs of the design alternatives under review. This will not only provide a more accurate measure of the cost effectiveness of the particular unit being studied, but also will show the cost variables that affect related designs, indicate any necessity for additional value study and help support the Value Design Review decisions.

Specification Value Review.

Every product has a specification of some kind. Many specifications, especially equipment specifications, incorporate requirements for use of one or more standards. An equipment that consists of several hundred components which is made by several processes and uses many different materials may easily involve hundreds of specifications and standards. However, the complete equipment can be obtained as a unit with one specification that describes the overall requirements.

Industry and government have classed specifications with adjectives such as performance, design, test, manufacturing, procurement and many others. Standards are identified by a name to indicate the issuing or controlling source. Depending on the complexity of the product and the intentions of the originator, any or all of the different types may be used to design, produce, test, and perhaps of greatest importance, prove that the item "works," and, therefore, is acceptable. Specifications are directly responsible for costs. They may be a primary source of poor product value and a primary obstacle to value improvement.

Specification Realism. Over specification leads to unrealistically high requirements that call for capabilities unlikely to be used, are expensive out of proportion to their contribution to final product performance, and may be obtainable only by compromising more useful capabilities. Under specification leads to failure in use. Yet, while specifications may be faulty, they are presently indispensable. If a specification demands capabilities that exceed the actual use requirements, an economic risk is incurred. This is because some units of production will fail to pass specifications, yet by virtue of a safety margin in the specifications, may still

be able to do the required job. These rejected, but usable, units not only constitute a waste, but necessarily raise the cost of those accepted. The ideal specification, from the producer's point of view, is one which all usable items can meet. The consumer incurs a more obvious risk whenever the specifications that govern acceptance of a product do not encompass all the demands of use. Products accepted as passing the specifications will later fail when exposed to the actual stresses of use, and again - loss. From the consumer's viewpoint, the ideal specification is one which non-usable items cannot meet.

It follows that design, procuring or accepting equipment with specifications that are non-quantifiable or that are not sharply defined has more elements of a guessing game than of a best value procurement.

Scope. The specification value review task is intended to cover the review of decisions associated with the selection, generation and modification of specifications prior to approval, release and use. The reviews should cover the specified requirements in terms of their absolute quantities, tolerances and the selection of other specifications as applicable documents incorporated by reference in whole or in part. Detail Specifications are especially suitable subjects for value review. Product Specifications and Equipment Specifications are the kinds of Commodity Specifications that are appropriate for review of requirements. Materials Specifications and Process Specifications generally are reviewed for their use as applicable documents.

Task Description. The specifications value review task is to perform a timely analysis of the associated specifications in order to identify and to initiate remedy of those elements not consistent with good value. A specification and each element or requirement it contains may be broadly classed as one of the following:

a) An Essential Characteristic - a characteristic which represents the minimum operational, maintenance and reliability needs of the user which must be fulfilled.

b) A Desirable Characteristic - a characteristic which is not essential but which will improve the performance, reliability or maintainability without excessive cost or complexity.

c) An Undesirable Characteristic - a characteristic which is not essential and which will result in unduly high cost or complexity, or will degrade essential characteristics. (Some of these may be apparent only after the complexity of the design and the costs involved are established.)

Application. Specification Value Reviews may be done on any project or program that is characterized by specifications which control any stage in its acquisition. These reviews may be a separate task or they may be combined with Design Value Reviews.

Timing. Research and development programs are especially suitable for specification review in their earliest phases. Department of Defense agencies have an opportunity for specification review prior to the issuance of requests for proposals, especially those for study and development contracts. The preparation and pricing of proposals for design and feasibility studies (e.g., program definition phase) deal mostly with specifications rather than hardware. Early stages of development programs offer opportunity for specifications and design review combinations.

Techniques. The techniques of analyzing a specification for its value considerations are substantially the same as those for a hardware value engineering study. The specification task is more difficult to perform since the object it pertains to may not be in existence yet. This does not preclude the applicability of the value engineering theory of comparing function, cost and worth; it simply means that a more intensive effort is needed.

A starting point for the application of value engineering principles is to determine the cost consequences, quantitatively if at all possible, of each requirement which is specified and each applicable document which is incorporated. The extent to which requirements are specified has a two part effect upon total cost. The first is the cost effect of the absolute magnitude, e.g., the number of degrees farenheit called out as 800°F as opposed to, say, 700°F. The second is the cost contribution of the allowed tolerance on the absolute magnitude, e.g., ±5°F as opposed to ±25°F. The cost consequences of adherence to the referenced specifications should be determined in a similar manner.

Specification Value Review Check List. A check list may be used to facilitate self-review by the specification generator and formal acceptance by a Specification Value Review Board. This list should indicate complianc

with the determination of cost consequences and functional worth. It may be prepared with appropriate questions listed for each major section of the specification: Scope, Applicable Documents, Requirements, Quality Assurance Provisions, Preparation for Delivery and Notes.

A check list will probably need to be prepared for each particular project or hardware type involved. For example, check lists for specifications dealing with an air filtration cartridge for manned spacecraft would have some significant differences compared to those for a portable flame thrower. However, certain general features may be identified which are common to all reviews of specifications. Each review should assure that the following have been considered:

a) Is the specification essential?

b) Is its resultant cost effect upon the product comparable to the worth of the benefits gained by the specification?

c) Is each specified requirement essential?

d) Is the resultant cost effect of the magnitude of each needed requirement comparable to the worth of the benefit gained?

e) Is the resultant cost effect of the tolerance specified on each requirement comparable to the worth of the benefit gained?

f) Is the resultant cost effect of each referenced or incorporated specification comparable to the worth of the benefits derived? (The referenced specifications that are major cost contributors may also need to be reviewed part by part as above.)

MATERIEL VALUE PROGRAM

This section deals with the organizational entity that procures services or equipment from external sources for a monetary consideration. In industry the usual nomenclature for this group is "Purchasing." This Guide uses the term Materiel to cover the various names used by industry and the DoD. About fifty cents of each prime contract dollar is spent with outside vendors, suppliers and subcontractors. DoD agencies annually disburse large sums for direct purchases of many commodities. An active value engineering effort in the organization that directly "spends" the money is a requisite element of an installation's comprehensive value engineering program.

Organization.

There should be a designated value engineering element in the materiel organization in addition to any other assigned value group elsewhere at the installation. Its level and reporting point can not be specified here. It should report at the level and place where command or management feels it will most economically accomplish its purpose. It should be staffed by one or more full time personnel. It is desirable that these personnel have engineering backgrounds, especially at their present location.

Tasks.

Exact descriptions for a Materiel Value Program cannot be given in this Guide as they will depend to a large measure upon the nature of the parent organization. In general, the tasks will fall into two categories: a) those which deal primarily with outside suppliers (vendors, contractors or subcontractors) and, b) those which interface with in-house personnel. Some typical tasks will be discussed as guidelines for establishing specific implementation procedures.

Supplier Category Tasks.

Value Engineering Familiarization. The task involves the efforts necessary to assure that each current and potential supplier is familiar with the value engineering discipline and the in-house value program. Each supplier's value program status needs to be known and assessed. Positive provisions need to exist for assisting suppliers to develop their internal value engineering capability. These may be accomplished by a combination of the following: a) invitations to attend in-house training, b) formal familiarization sessions for invited suppliers, c) bulletins and newsletters, and d) specific questions on vendor survey forms and procedures.

Administration of Contractor or Subcontractor Value Programs. Major contracts and appropriate subcontracts should be evaluated for the type of coverage needed. Contractor performance should be monitored as the contract proceeds. Value engineering change proposals need to be followed through their submission to final disposition.

Supplier Value Engineering Suggestions. A formal process should be developed to obtain input from suppliers on procured parts and services. This may be accomplished by a Value Check List sent out with each request

for quotation, purchase order or data package given to prospective suppliers. Displays may be prepared of current items on which value suggestions are desired and placed in the lobby that suppliers use.

In-house Category Tasks.

Training. The materiel value engineering personnel serve as the focal point for supplier aspects of in-house training. This includes: a) assistance in selection and contact of vendors to take part in the workshops, b) provisions for obtaining vendor quotations during the workshops, c) supplier data for workshop data packages on outside purchased items, d) recommendation of possible workshop projects from among current purchases, and e) lecture support.

Value Studies. This task is concerned with the performance of in-house value engineering studies. The materiel organization has two general responsibilities: a) serving (or providing personnel to serve) as Task Force members and b) selecting, initiating and performing studies of projects from current or potential outside purchases.

Cost Visibility Support. The materiel function possesses vast quantities of cost data. Unfortunately it is usually in much finer detail than can be effectively used by designers during hardware development and by other action level personnel. A logical task for the materiel value engineering personnel is to condense and distribute these data for use in the overall cost visibility effort. For example, average cost data for various outside purchased fabrication processes could be prepared on a per pound basis with the quantity cost break points and standard tolerances. This would facilitate economic choice during the drawing preparation stage.

PROJECT REQUIREMENTS EVALUATION

The Projects Requirements Evaluation task contains some aspects which are common to other tasks previously discussed. Certain portions of this task are also common parts of the normal routine of daily business. However, its use as a formal, identified task with an assigned responsibility is appropriate at certain points in the acquisition process.

Description.

Projects Requirements Evaluation is the task of assuring that all of the specified compliance criteria associated with a contract, procurement

or program are in accord with the principles of best value. Its performance entails: a) identification of planned or existing requirements, b) evaluation of them, c) isolation of excessive and unneeded requirements and, d) the initiation of corrective action. This description is similar to the specification and design review tasks. However, it encompasses all of the obligatory elements of a situation rather than just the specifications or the designs. It also examines these criteria as an entity rather than piecemeal.

Requirements.

Sources. This task is suitable for performance with respect to the requisite elements contained in any or all of the following sources associated with a particular procurement:

a) Request for Proposal.
b) Invitation for Bid.
c) Proposal.
d) Statement of Work.
e) Contract Schedule.
f) Contract General Provisions.
g) Program Plan.
h) Subcontracts.

DoD agencies have the opportunity to evaluate these sources prior to their issuance. Industry attention to this task must come after the fact but would still be considerably prior to the start of any fabrication.

Types. All obligatory elements written or incorporated into the source documents are susceptible to this evaluation. A partial listing of typical types follows:

a) Hardware quantity.
b) Spares selection and quantity.
c) Specifications.
d) Exhibits.
e) Standards.
f) Data and documentation selection quantity and format.
g) Approval points.
h) Test, acceptance, packing and delivery.

Procedure.

The procedure may be defined as a series of four steps: a) identification of requirements, b) isolation of unrealistic requirements, c) analysis, and d) initiation of corrective action.

Identification. This step entails detailed examination of all sources of specified mandatory elements associated with the procurement. A list of

the title of each requirement is prepared and then grouped according to its type as noted above. A very short statement of the nature or quantity that each requirement represents is placed with each item on the list. The analyst must become familiar with each listed element.

Isolation. This step is similar to the selection of value engineering projects. However, the intangible nature of words (which is all that is available for this task) requires attention to their implications. The sorting is done by examining each listed compliance criterion for any possible anomalous situations:

a) Applicability of each requirement to the technology of the procured product (e.g., specifications intended for spacecraft required on ground training simulators, or vice versa)

b) Quality and reliability levels beyond the most probable needs.

c) Environmental requirements not typical of the application (e.g., shipboard shock environment called out for equipment to be used in shipyards).

d) Requirement of identical quantities of all reports of all types.

e) Development of new or specialized items that would seem to have been available from previous DoD or commercial programs.

f) Seemingly incongruous requirements for advanced state of the art processes.

g) Any redundant requirements (those that seem to already have been satisfied, in whole or in part, by another requirement in some other place of the program)

h) High cost requirements (those that are the largest cost contributors).

Analysis. Analysis of the mandatory items suspected of poor value is done by using the value engineering theory of function/cost/worth comparison. Value studies or task forces may be the vehicle to carry the analysis. A report of recommendations is the normal output.

Initiation of Corrective Action. The report which is produced by the analysis step should include the details of corrective action. The corrective action procedure will depend upon the procurement, the time phase at which this task is performed, and who performs it, i.e., the DoD or a contractor. In any event, this task includes the responsibility that proper corrective action is brought to the attention of those with the authority to take action.

PROGRAM ELEMENTS: SUMMARY

A. Value engineering program elements are identifiable tasks that represent value engineering theory reduced to practice and are performed wholly or partially by value engineering personnel.

B. The base for value programs is value engineering training in varying degrees for all personnel whose decisions affect DoD item cost in order to provide capability for self application of the principles of best value.

C. Value Studies are the investigations of selected projects by a value engineer in accord with the Job Plan to produce reports which recommends a lower cost alternate.

D. A Task Force is an ad hoc group of personnel selected from value engineering, materiel, production, engineering, finance and other areas to perform a value engineering investigation of a specific item.

E. The Cost Target task entails the preparation of end item cost goals and periodic comparison with the predicted fabrication cost during the design and development phase.

F. The Value Review program element is the effort necessary to provide positive procedures for the consideration of value engineering principles during design and specification reviews.

G. The implementation of value engineering with respect to outside purchased parts, suppliers, contractors and the support of in-house needs for outside cost data are the main elements of the Materiel Value Program element of the total value program.

H. Projects Requirements Evaluation is the task of applying the value engineering principles to all obligatory criteria of a procurement as included in the RFP, proposal, statement of work, contracts and referenced documents.

Chapter 5: Workshop Projects

This Chapter describes the practical exercises to be used in value engineering workshop training...distinction is made between training for improvement of existing designs and training in the application of value engineering during initial design...The structure of project teams, their tasks...and desired results are also presented...Guidelines are offered for the selection of workshop projects... seminar presentations on the final day are described... reference to additional sources of information for project work exercises are included.

CHAPTER 5

WORKSHOP PROJECTS

OBJECTIVES

The primary purpose of the project work exercises is to provide an opportunity for learning by actual application, thus increasing the benefits to be derived from the training experience.

The project exercise usually will result in suggestions for improvement in the project's value, especially by cost reduction. Total figures of these possible cost reductions are sometimes quite impressive when compared with the cost of training. The student's attempt to report large potential savings, however, should not influence project activities to the detriment of the technical competency of the proposals. Evaluation or grading of student training results should be based upon demonstrated understanding of the application of the value engineering method. However, the possible cost advantages should not be disregarded simply because training is the major objective.

Team Concept.

Students are grouped into teams and each team is provided with a preselected project. Approximately half of the workshop class time should be scheduled for project work. Acting as a team, students apply the lectured, or theoretical, portions of the training to the actual project and so perform a practical value engineering study. Studies should be pursued to a sufficient state of completion to permit preparation of a written report and an oral presentation on the last day of the workshop.

The technical material needed to accomplish the value engineering portion of the team project is contained in this Guide. Technical and procurement information about the project item must either be provided to the team as part of a prepared package or must be available on the site via personal contact or telephone.

Relationship of Projects to Personnel Job Duties.

Value engineering training should reflect the differences between its application to the design, or R & D phase of acquisition, and to other phases characterized by already conceived hardware and data. This is accomplished by choosing value assurance training projects for personnel who are concerned primarily with the "upstream" portions of defense procurement and value improvement projects for the others. The objective of both types of value engineering projects is to have the team produce a solution which represents best value.

Value improvement projects seek this objective by using preconceived solutions (such as a hardware item, a test procedure, a manual, or a paperwork system). The team analyzes the project and produces a recommendation ranging from complete elimination to re-creation at lower cost than the original article.

Value assurance projects provide the trainee with only the basic requirements, criteria or parameters which need the creation of a solution. These requirements may be in the form of the physical envelope, weight limits and performance specifications for a simple hardware element. Or, a written description of the need for a paperwork system to perform a function may be used. For example, a need for quality control data feedback from the vendors to the prime contractor project office representative and on to the Department of Defense project office.

The team analyzes the requirements and develops a solution which it can demonstrate as offering good value. When the team has completed their value assurance project, their results may be compared with the current actual solution (e.g., the hardware in use) or with the solutions proposed by other teams from previous value training exercises which used the same project.

TEAM STRUCTURE

The students should be divided into teams of five to eight persons according to the nature of their assigned project. The smaller teams are for items which are to be value-improved and for non-hardware projects; the larger teams are more suitable for value assurance projects. Team members should be chosen so that each team represents a "mix" of work experience and education. Each team should consist of an amalgamation of members having the following backgrounds or current work assignments: a) engineering, b) procurement, materiel or logistics, c) production, d) quality control, and e) additional members drawn from other backgrounds. This must be determined by a pre-workshop evaluation of the project's value problem areas. Other personnel may include reliability, administrative operations, contracts, project office, or more than one representative of the three basic types. (Obviously, prior to the seminar some measure of attention must be devoted to coordinating the selection of students, projects and probably team structures.)

The team members need not be experts in the technical aspects of their project. However, their level of this knowledge does need to be greater for value assurance projects than for value improvement projects. Access must be available on site to personnel who have expert knowledge of the project. Generally, it is not good practice, from a training effectiveness viewpoint, to have people on the team who initially created the assigned item.

PROJECT SELECTION AND PREPARATION

Projects need to be selected and prepared several weeks in advance of the first day of the Workshop. Table 5-1 gives some desirable features of value assurance and value improvement projects. In the case of value improvement projects, it can be especially useful if the original creator will agree to its use and will support the team effort. For value assurance projects, the person choosing the projects should estimate some of the likely resultant characteristics of the most probable solutions. This will not be necessary if a solution has in fact been created, but is withheld from the team until the completion of its effort.

Table 5-1. Guidelines for Selection of Workshop Projects

An assembly of 5-50 detail parts.	Unclassified.
Performs a recognizable function by itself.	Opportunity exists for incorporation of team results.
Size and weight allow handling by one person.	Present or anticipated total cost per procurement or per year is large enough to achieve meaningful dollar results.
Sample items or mockup are available.	Prejudged as feasible of successful application of value engineering.
Drawings, specifications and data are available.	Exhibits apparent low value

The teams must be provided with Project Data Packages. These contain the data needed to begin the study. They serve to reduce much of the "start-up" delays associated with routine gathering of paperwork. Typical items of data which might be involved are listed in Table 5-2. Naturally, only those elements of data which are associated with the requirements portion of the item are included for value assurance projects.

PROJECT WORK

The team members follow the Job Plan. They perform a value engineering study and recommend a higher value item for value improvement projects and create a high value item for value assurance projects. They perform each phase in turn and they should satisfy themselves that they understand the application of the theory. The team should divide up those elements of the workload suited to their personal capabilities. Items suitable for individual assignment include the cost model, requirements analysis and evaluation of the separate proposed solutions. However, the team as a whole should perform the functional analysis, the development of alternatives, agree upon the cost target and the alternative selected for proposal.

Vendors may be provided with direct access to the training area on selected days. They will assist the teams in their development and selection of alternates. Judicious selection of the number and types of

Table 5-2. Typical Workshop Project Data Package Contents

Drawings, Layouts or Sketches

- Next Assembly
- Assembly Drawing
- Detail Parts Drawings
- Schematics

Costs (Actual and/or Anticipated)

- Tooling
- Raw material
- Outside purchased parts, tooling
- Inspection
- Fabrication
- Assembly
- Any other significant elements

Manufacturing Planning and Status

- Tooling Description
- Handling Equipment
- Planning Sheets
- Scrap Loss Data
- Lot Size
- Packing and Shipping

Contract Data

- Incentives
- Quantity Required - Basis for Cost Calculation
- Anticipated Future Quantity

Procurement Data

- Participating suppliers or contractors
- Previous or current proposals
- Anticipated procurements

Contact Points (name, location, and phone)

- Designer
- Buyer
- Cost Analyst
- Contracts

Specialty Consultants

- Technical Theoritical aspects
- Fabrication
- Quality
- Field Services

Specifications (Performance, Model, Process, Other)

- Department of Defense
- Contractor
- Subcontractor

Design Criteria and Status

- Intended application and purpose
- Weight
- Reliability
- Space envelope

Highlights of Past History

- Design history
- Fabrication history
- Procurement history
- Associated documentation
- Manuals
- Handbooks
- Reports
- Photographs
- Failure reports
- Service records

vendors can improve the effectiveness of this phase. Liaison should exist to promptly provide verification of vendor prices for use in the team report.

The final step of the procedure, as stated in the Job Plan, is to prepare a team report. Each member need not prepare a separate report, but each section should be marked with the name(s) of those who prepared

it. The report should clearly demonstrate the students' application of the value engineering methods and program elements.

Team Project Presentations.

The value engineering project work may include an oral presentation on the last day of the workshop. Instructors may select several or all of the teams to make presentations.

Audience and Facility. The audience for the presentations should include all trainees and those who will be reviewing the team's recommendations for approval and implementation action. The presentations should be made in a room where outside distractions will be minimized, where the speakers can be seen and heard, and where a comfortable listening environment exists. Invitations to attendees should come from a senior manager of the installation and should convey his personal interest. The presentations should start promptly on schedule, maintain a business-like pace, and adjourn on schedule. Attendees should leave the meeting with an enthusiastic desire for more information, rather than with a bored attitude. Effective team presentations are one factor in successful training and in implementing the team results. The oral presentations should have been reviewed by the Workshop training staff prior to the last day.

Content. Team presentations should include the following elements:

a) Identification of the project by name, date, and location.

b) Identification of the participating team members, including the preferred point of contact for further details. (This can be accomplished on one visual aid, such as a flip chart.)

c) Concise statement of the reason for the project, the cost and other problem areas, and the end-use of the project item.

d) Brief summary of the main alternatives considered by the team, including pertinent comments regarding principal factors for their acceptance or rejection.

e) Description of the recommended changes in sufficient detail to communicate cost advantages and the effect upon other considerations, such as reliability, producibility, tooling, schedule time, scrap, etc.

f) The action items required for implementation.

g) Description of the value engineering techniques which were used in the study, and the ways in which they were applied.

Visual Aids. Visual aids, in the form of flip charts or simple mockups, are generally used to supplement the oral reports. These aids will: a) provide the same function as personal notes and help the speaker to stay on course. b) assist in emphasizing key elements of the presentation, and c) create a "hear-see" environment which brings into play a dual receptivity channel.

The adherence to specific guidelines for the preparation of visual aids will make them more effective. Books or pamphlets which suggest the number of charts, size of lettering, sketch techniques and other aspects should be made available to the trainees. The aids should not add cost to the workshop which is unnecessary for performance of the basic function.

Organization of Material. The organization of the oral presentation should closely parallel that of the written report. It should show the step-by-step process of the Job Plan as the project was developed. The concluding portion of the presentation should include specific implementation recommendations. No attempt should be made to have a detailed technical discussion of the operation of the project item, other than a brief statement of its function.

Timing. The appropriate length of time allowed for each team's oral report will depend upon the number of presentations. In recognition of the reality of the statement that, "The mind will absorb what the seat will endure," the total time for all of the presentations should not be more than two hours. If six team reports were being made, each team should be limited to ten minutes to allow delay time and comments. On the other hand, a single presentation could take as long as thirty minutes, provided unnecessary material is not incorporated simply to use up time. Emphasis and timing of oral reports should always reflect the proper balance between required subject matter and maintenance of full-level audience receptivity.

INFORMATION SOURCES

The reference sources described below will be useful in the performance of the project work. They will be especially helpful during the evaluation and proposal phases of the Job Plan. They will also provide a good reference that may be readily used later during the implementation phase

when follow-up is being performed. Personnel who may not have participated in the study may need to research the team's references.

Catalogs.

Most suppliers specialize in certain parts, products, components, materials or processes. Their catalogs include parts data on demensions, materials, finishes, weight, testing, specifications, standards, and in some cases cost. Catalogs of nondefense industry companies, especially the large mail order houses, are good sources of comparative data on commercial equivalents of defense products.

Technical Magazines and Journals.

There are various technical magazines and journals which generally specialize in a particular area of engineering, manufacturing, procurement, or product line. These contain a variety of articles describing the latest state-of-the-art. Numerous vendors' advertisements cover new parts, products, materials, processes, and also serve as possible sources of alternative approaches.

Sweets' Catalog Service Files.

Approximately ten volumes of Sweets' catalogues are arranged by subject matter into; plant equipment, machine tools, metal working equipment, industrial construction, product design and the respective suppliers. The two product design volumes are broken down into:

a) metals
b) plastics
c) rubber
d) glass, ceramics, silicones
e) wood, carbon, fabrics
f) electrical equipment
g) power transmission
h) fluid power, flow equipment
i) fasteners, adhesives
j) mechanical equipment and services.

Thomas Register.

The Thomas Register has a complete alphabetical list of industries and suppliers grouped under parts, products, materials and processes. It also contains addresses of suppliers and lists trade names and brand names for many common items.

Conover-Mast Purchasing Directory.

The Conover-Mast Purchasing Directory is similar to the Thomas Register. It has product classifications, mechanical data, chemical and trade name sections. It also contains suppliers telephone numbers.

Electronic Buyer's Guide.

The Electronic Buyer's Guide has alphabetical product listings plus trade names. It lists manufacturers and users of electronics products. Organizations are identified that issue electronics standards.

Electronic Engineer's Master.

The Electronic Engineer's Master is a catalog and purchasing guide of 6300 manufacturers of electrical and electronic equipment, products and trade names.

Military Specification Buyers' Directory.

This directory categorizes products and materials under their respective military specifications. It also lists the suppliers of these products and materials and the military specifications they meet.

Visual Search Micro-Film Service (VSMF).

Parts and components data are on microfilm. An attached catalog is used to locate the proper cartridge with the described film. A microfilm reader is part of the system. The reader has built-in capability for making a standard page-size copy for personal retention.

CHAPTER 5: SUMMARY

A. Workshop projects are practical exercises in the application of value engineering by seminar trainees acting in teams. They follow the Job Plan under the instructor's guidance and prepare a report of value engineering recommendations at the workshop conclusion.

B. The primary purpose of workshop projects is to provide a controlled environment for a practice exercise in the application of the theory.

C. Workshop projects need to reflect the trainees' normal job assignments as typical of either value assurance or value improvement. Value assurance project work starts with a written requirement; value improvement project work starts with a written requirement; value improvement project work starts with an already pre-conceived solution to some requirement.

D. Oral presentations should clearly demonstrate the value engineering methods and procedures used.

E. Information source books, rapid vendor liaison and technical consultation should be readily available to the team members.

Chapter 6: Systems Management Interfaces

This Chapter introduces some industrial and DoD management disciplines which have common boundaries with value engineering. . . their operational procedures. . . inputs. . . outputs. . . and effect upon end item cost are discussed. . . Possible applications of their activities to value engineering efforts are offered. . . and some areas of common purpose are noted for. . . Systems Requirements Analysis. . . Configuration (or Change) Management. . . Data Management. . . PERT and PERT/Cost. . . and Specifications and Standards.

CHAPTER 6

SYSTEMS MANAGEMENT INTERFACES

The DoD and industry have developed some highly specialized disciplines for use in the acquisition of defense inventory items. Some of these disciplines are recent developments and others represent gradual adaptive improvements of standard practices. Five operational procedures were selected for discussion in this Guide which meet one or more of the following criteria:

a) they are usually applied to procurements which also represent good value engineering application opportunities.

b) their activity generates data which can serve as inputs to the value engineering effort.

c) their decisions have a significant effect upon end item cost.

These factors are interfaces with value engineering. Their use needs to be understood to obtain the most efficient operation of value programs, especially value assurance efforts. The management disciplines discussed are not applied to all programs. When used, the terminology is not always constant for all programs. This Guide will present them in their standardized form when this exists and in as typically generalized a form as possible when it does not. The purpose here is to understand their operation for their impact upon value engineering.

SYSTEM REQUIREMENTS ANALYSIS

System Requirements Analysis (SRA) is the process of developing end item requirements for all elements of a project (especially a weapons system) including the hardware and software. The constraints imposed by

the acquisition, installation and operation requirements of the entire system are used. The constraints are: a) technical, b) design, c) cost, and d) schedule. The sub-system requirements that are developed may be broadly classed as: a) equipment, b) facilities, c) personnel, and d) procedures. SRA is applied early in the development phase and maintains system integrity during sub-system development.

The development and implementation of the requirements must be timely, must optimize performance, and must make the most effective use of resources. To accomplish this goal, it is necessary to identify the items which will comprise the system on a total system basis. Included in the total set of requirements are those which are imposed by performance, cost, functional and physical interfaces, power, size, weight, personnel skills, and environment. The requirements set for these parameters must reflect specific needs imposed by such related disciplines as maintainability, operability, human factors, and safety.

<u>System Model.</u>

The data produced by the SRA provides a "paper" weapon system which is a model of the operational system. It is a model of the system in two respects: first, as a system description; and second, as an input to a dynamic model for system simulation. The system description is the basis for many other system outputs, such as Technical Orders, Quantitative and Qualitative Personnel Requirements Information, and test and activation planning. The description also defines a baseline which can be used for conducting trade-off studies, system optimization studies, and evaluation of system parameters and proposed changes.

<u>Method.</u>

SRA is an iterative process of the following steps:

a) Identify and categorize the criteria applicable to the system - i.e., what is the mission and what are the constraints and resources?

b) Develop functional relationships for sequential groups of sub-tasks or functions necessary to accomplish the mission.

c) Analyze the functions and identify related requirements.

d) Synthesize alternative approaches to performing the functions, conduct trade studies, and parametric optimization studies.

e) Evaluate study results and define selected system parameters.

f) Provide identification of equipment items and requirements for facilities, personnel, and procedures.

The flow of typical SRA activities is shown on Figure 6-1. The matrix in Table 1 of the flow chart lists the system criteria and constraints which are inputs to the analysis. These are analyzed and further developed to determine specific detailed requirements for operational and maintenance hardware and software. The end items identified by the input criteria and their constraints are determined. The operational and maintenance portions are integral parts of the analysis.

Initially, the functional requirements are identified and then trade-off studies are performed to apportion these functions among equipment or personnel. Maintenance studies are made to determine the levels of maintenance which must be performed, the maintenance equipment and personnel required, and the design features which are to be built into the operational equipment to facilitate maintenance. One of the final steps is the loading of the necessary quantities of equipment, personnel and spares into the system.

Outputs. Some of the outputs of the SRA are:

a) Functional Flow Diagram. It identifies those functions and functional interactions which must be performed by equipment, people, or some combination to meet the objectives of a given operational or maintenance mode.

b) System Functional Analysis. This develops technical requirements for the functions identified on the Flow Diagrams and provides personnel, facility and procedural data.

c) End Item Design Criteria. These identify the design criteria for each deliverable end item; such as, technical requirements, recommended solution, part number, unit price, and effectivity.

d) Equipment Maintenance Analysis. This identifies the maintenance functions necessary to support each end item, the basic maintenance functions (test, calibrate, service, handle, etc.), maintenance level and frequency, and maintenance personnel and provisioning data.

Figure 6-1. System Requirements Analysis Flow

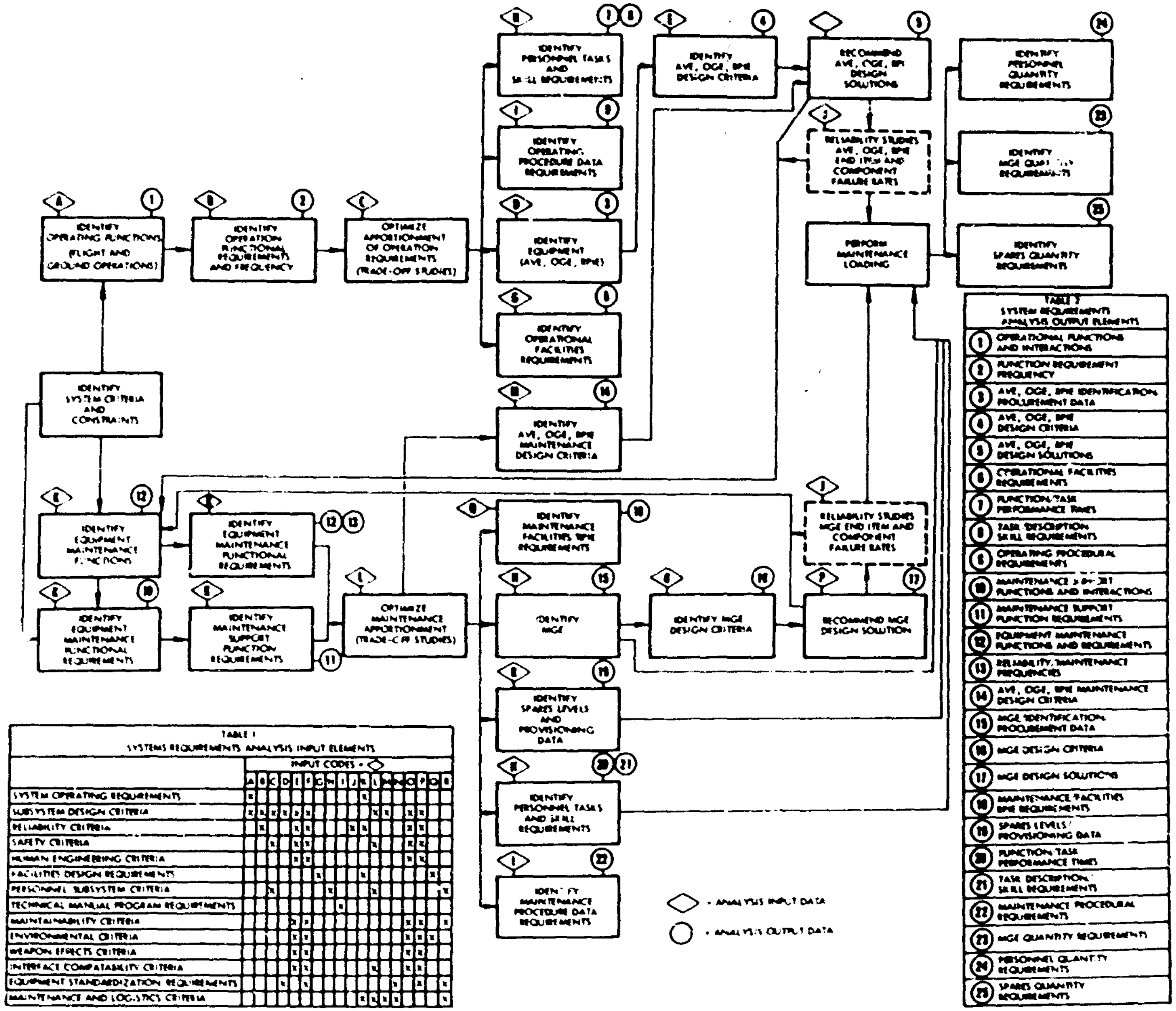


Figure 6-1. System Requirements Analysis Flow

e) Time Line Analysis. It shows the time required to perform operations involving time-critical functions, on-site maintenance, and selected field maintenance activities. The time line data is derived from the system functional and maintenance analyses and is used to determine reaction, usage, repair and down times.

f) Weapon System Description. It serves as a model of the system operation and maintenance based upon the analysis data. The description contains requirements and ground rules used in developing the analysis (e.g., work hours, levels of maintenance, etc.) and descriptions (drawings and text) of the weapon system.

g) Technical Manual Requirements. These define Technical Manual requirements based upon the system functional and maintenance analyses.

The relationship and content of the SRA elements are depicted in Figure 6-2.

Maintainability.

Maintainability is defined in the DoD as the qualitative and quantitative characteristics of material design and resource planning which make it possible to meet operational objectives with minimum expenditures of resources (personnel, equipment, and data) under operational environmental conditions. It may be effectively accomplished as an identifiable part of the SRA.

Design Considerations. Maintainability program aspects can be categorized into: a) those which relate to the design effort, and b) those which relate more directly to resource planning and evaluation. Design considerations are examined to determine their applicability from a cost-effective viewpoint to each item of equipment. This includes: a) interchangeability, b) packaging, c) mounting, d) accessibility, e) standardization, f) test points, and g) type of displays and controls.

Resource Considerations. The maintainability factors which relate more directly to the planning and evaluation efforts are: a) levels of maintenance, b) fault detection, isolation and reporting, c) repair, d) reliability apportionment, e) in-commission level, and f) quantities of equipment, personnel and spares.

The maintainability program is made an integral part of the system acquisition program to achieve the degree of maintainability that is most economically feasible. Specific goals, such as minimum support equipment,

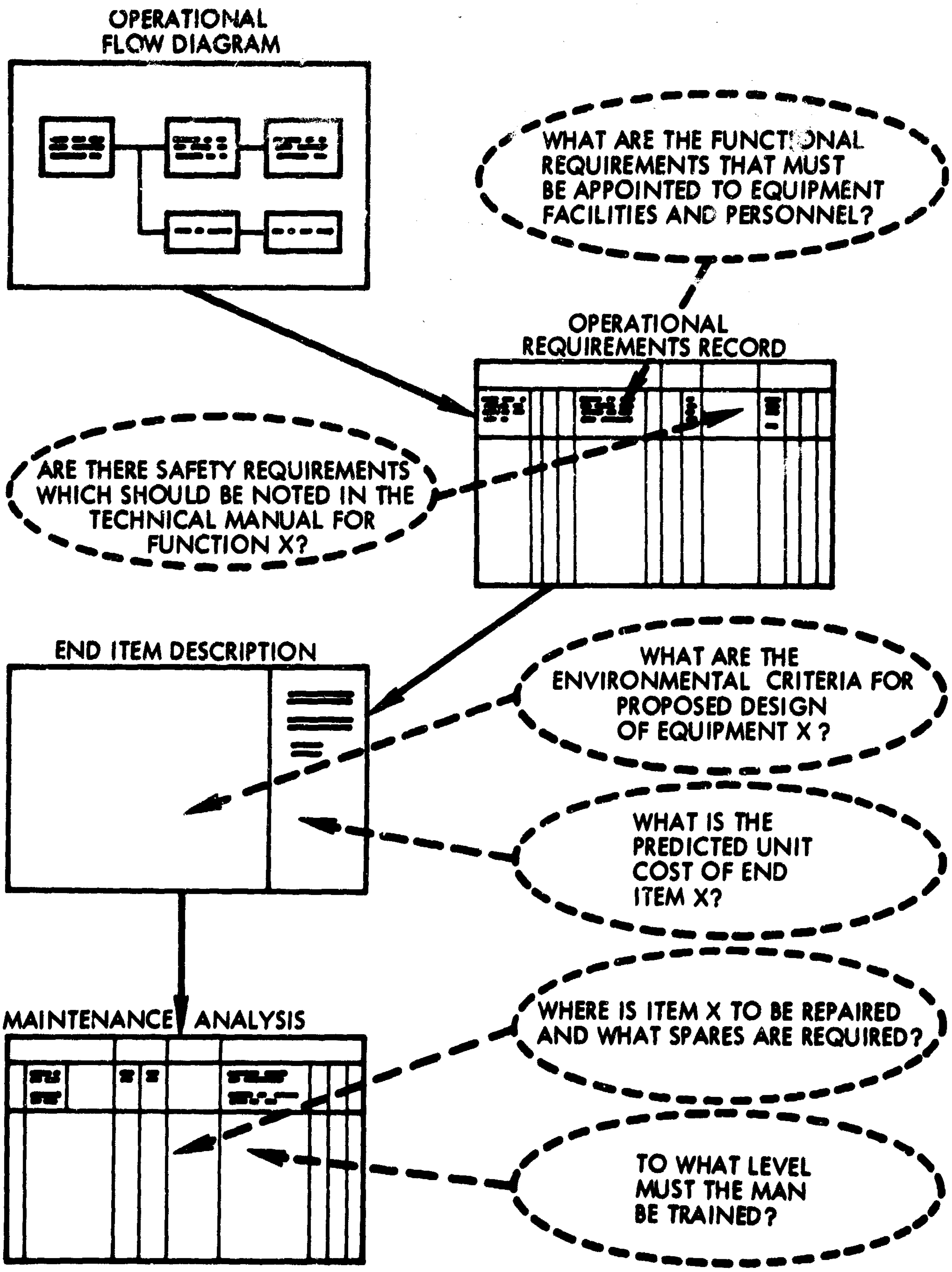


Figure 6-2. Some Outputs of System Requirements Analysis

personnel and cost, and maximum in-commission level are established and factored into the program during design and development.

Simulation.

A simulation program is useful to evaluate the degree of maintainability from a system cost-effectiveness viewpoint. Utilizing the basic SRA data, simulation with the dynamic model defines and demonstrates the effect on the system of shared resources such as equipment and personnel. The model looks at this consumption of resources in a time based sequence which follows the planned cycle of operational deployment and use. Computers are useful tools for performing simulation studies on the larger systems.

It allows a detailed look at the system as it is to be eventually used. It provides a rapid evaluation of whether the system will or will not meet the many operational, maintenance, and logistic requirements; one year of operation can be simulated in minutes. Many things can be done using the model which could not be done using the actual system, even if it were available. Input parameters can be varied, the maintenance approach revised, failure rates varied and the results quickly presented concisely.

Simulation Model. The model is based upon a sequence of logical events which depict the operational and maintenance activities which are to be performed. The sequence comprises fixed events that take place whenever the related initiating event occurs. The numerical values associated with each event may vary, but the sequence itself remains the same unless, of course, it is decided to vary the sequence to determine the effects upon the system.

Typical input data to the simulation model are:

a) Number of failure categories.
b) Failure rates.
c) Number and frequency of preventative maintenance categories.
d) Maintenance ground equipment (MGE) spares numbers and types.
e) Travel distances and speeds for maintenance responses.
f) Average personnel working hours per month.

Simulation Analysis. The factors above are given to the computer. It simulates the system by going step-by-step through the proposed system operation. The computer progresses to the next step in the model, if all

of the required conditions are met. For example, if a failure occurs, is the needed MGE available? If it is not available, the non-availability of the required resource is noted. Typical output data of the simulation analysis are:

a) In-commission level.
b) Total number of fault responses on which a support element was used.
c) Average number of each support element that was in use at any time
d) Reaction time to any given fault.
e) Average down time for each repair action.

Personnel Subsystem (PSS).

The people who are needed to operate and maintain the system are as much a component as the hardware. The personnel requirements are developed concurrently with the design of the equipment and facilities by PSS analyses as an integral part of the SRA. Human engineering critera are applied to achieve satisfactory personnel performance while holding skill and training requirements to a minimum. Task analyses are conducted to identify human performance requirements, task sequences, and required performance times. In addition, the information required to operate or maintain equipment, work-space layout, and design criteria (such as the type of controls and displays required) are developed.

Interface With Configuration Management.

The SRA supports the identification and management of the system configuration in several ways. First, it identifies the total set of requirements which define the system. Second, it provides the design effort with end-item design criteria and serves as a check on the resultant designs. Finally, it provides a means for determining the effect on the system of a change in hardware design. If, for example, the design of an item of operational ground equipment (OGE) is modified, the SRA determines any possible effects on the related Maintenance Ground Equipment, personnel and facility requirements.

A typical sequence of the interrelated events is:

a) Identify new or modified requirements.
b) Prepare and submit end item design criteria and related analysis.

c) Review and technically approve analysis.
d) Prepare and submit a change proposal.
e) Review and approve the change proposal.

The system requirements are thus controlled and any change to the system baseline is supported by analytical justification.

The SRA defines a system configuration baseline as a controlled input to later analyses. For example, the SRA baseline developed for the development system can be utilized to define activation (assembly and check-out) and test requirements. For example, a test set built for development use may also be used in the activation and checkout of the operational system. The procedures used during the test program can be directly derived from those procedures which will be used operationally. This assures maximum correlation between the test and operational programs.

Personnel.

The analysis to identify the system requirements is performed by system engineers. This effort leads up to the detailed development of the solutions to the requirements. The development of the solutions is accomplished primarily by design engineers. The type of engineer; electrical, mechanical, or facility, depends upon the specific design problems to be solved. The trade studies often require the services of people of varied backgrounds. These studies may call upon personnel from a system engineering, design, human engineering, cost analysis, or programming background. In addition, throughout the analysis, inputs to the various disciplines such as maintainability, value engineering, human engineering, and safety are made. The outputs from these disciplines are then integrated into the SRA effort.

CONFIGURATION MANAGEMENT

All DoD organizations do not use the same details or nomenclature in the management discipline of controlling end item changes. However, the approach presented in this Guide is considered to be typical and, with minor variations, represents actual practice. For example, this Guide uses the term "Configuration Management." Some agencies use "Configuration Control" or "Engineering Change Control." The reader needs to adjust his frame of reference for such situations.

Description.

At the outset of a new defense system, the technical concept and criteria will have few details. But as development progresses, the details begin to fill in. The system and its parts are defined by drawings, manuals, procedures and other data. The need for changes to some items arises. New items are needed that were not previously realized. Configuration management is the discipline applied to selected procurements to assure that the initial description, additions and amendments are controlled so that the technical description constantly reflects the actual system.

As an example of a typical system, the following major equipment items may be involved:

a)	Propulsion	f)	Trailer
b)	Airframe vehicle	g)	Test equipment
c)	Re-entry vehicle	h)	Handling equipment
d)	Launch control equipment	i)	Facility (Brick & Mortar)
e)	Launcher	j)	Guidance and control equipment

Each of these ten equipment requirements may be contracted to individual sources, each with their own configuration management approach. The need to have a controlled interchange of technical information is obvious. Concurrent activity makes commonality of configuration control mandatory so that interfaces between the various equipments are maintained to meet the overall system program requirements.

Configuration management offers a system by which this exchange can be accomplished. It is common reporting language. It helps the contractor develop internal reporting systems which are compatible with the known reporting needs of the Government.

Definitions.

a) Configuration.

The complete technical description and identification of the requirements for fabricating, testing, accepting, operating, maintaining and logistically supporting systems or equipment, e.g., end item part numbers and descriptions, top assembly drawing numbers, indentured parts lists, model, test and performance specifications, maintenance, training and operation instruction manuals, recommended spare parts lists, and packaging instructions.

b) Configuration Management.

The formal set of procedural concepts by which a uniform system of configuration identification, control and accounting is established and maintained.

c) Baseline Configuration.

The complete technical description of a predetermined unit of a system or equipment which is established and documented as a point of departure against which proposed changes may be evaluated, implemented and recorded.

d) Configuration Control.

Systematic evaluation, coordination and approval or disapproval of all changes to the baseline configuration.

e) Configuration Accounting.

Reporting and documenting changes made to system or equipment after the establishment of a baseline configuration.

f) Configured Articles or End Items.

The portions of a system to which configuration management is applied.

g) Engineering Change Proposal (ECP).

A contractor proposed change to an end item, facility or part; delivered, or to be delivered; which will require revision to the contractually authorized specifications, engineering drawings or other pertinent documents.

h) Class I Change.

An engineering change is designated as Class I and is submitted as an ECP to the Government agency's Configuration Control Board (CCB) for approval when any of the following contract requirements are affected:

(1) Specifications, price or fee, weight, guarantees, delivery or test schedules.

(2) Reliability or maintainability.

(3) Performance.

(4) Interchangeability.

(5) Safety.

(6) Electrical interference.

(7) Ground support equipment, training equipment or government furnished equipment.

(8) Preset adjustments or schedules to the extent that a new identification must be assigned or operating limits are affected.

(9) Interface with other contractor's equipment.

(10) Operational computer programs.

i) Class II Change.

All engineering changes that are not Class I are designated as Class II. Class II changes do not require government agency approval but are subject to review regarding their Class II designation. Typical Class II changes are those which:

(1) Change the processes by which a part is fabricated but do not change its configuration (i. e., its fit, form, or function).

(2) Correct obvious drawing errors, such as misspelled words.

(3) Change views or notes on a drawing for clarification.

(4) Relax or tighten tolerances without affecting interchangeability.

Operational Aspects.

Three aspects of configuration management may be identified as:

a) Configuration identification and accounting - have available at all times accurate and current information regarding the exact configuration of all configured articles.

b) Change control - establish and maintain procedures and activities which will assure fast, complete and accurate analysis of proposed changes and their incorporation.

c) Change administration and planning - implement the processes by which changes are handled, incorporated and documented.

Implementation Procedures.

Contractor. The contractor Program Office establishes a Change Board, which sets a terminating point during the design activity where formal accounting of changes to configured items shall be initiated. This is the development, or contractor configuration, baseline. It covers the following requirements:

a) Specific operational and maintenance requirements.
b) System specifications.
c) Model specifications.
d) Proposed configured items.

DoD. The Government agency program director establishes a Configuration Management Office. It is responsible for:

a) Issuance of Government approved systems requirement documents such as a System Operational Requirement (SOR) or Advanced Development Objectives (ADO).

b) Preparation of approved system and equipment specifications.

c) Participation with contractors in systems analysis to select the configured end items.

d) Implementation of a research and development specification for the performance, design and test requirements of each end item which will serve as the basic contract documentation.

e) Implementation, review and validation of the uniform specifications for each "first-of-a-kind" end item.

f) Establishment of First Article Configuration Inspection (FACI) or First Article Review (FAR) Team and performance for each configured end item.

Configuration Control.

The focal point of configuration control by the contractor is a Change Control Board. It is normally chaired by a Manager of the Program Office. Generally it is co-chaired by a representative of the Engineering Department who has cognizance for the equipment items affected by proposed changes.

Typical Contractor's Change Board. Appointed representatives may be from the following areas:

- Program Office, Chairman
- Engineering, Co-chairman
- Production (Manufacturing Operations)
- Production Control (Scheduling, Stores, etc.)
- Quality Control
- Reliability
- Specifications
- Product Support (Logistic, Manuals, Handbooks, etc.)
- Contracts
- Government Agency Resident Officer
- Value Engineering
- Materiel
- Sub- or associate contractor representatives

The Change Board's principal responsibility is to analyze all proposed changes and their impact on: a) contract requirements, b) technical requirements and feasibility, c) cost and d) schedule. The Chairman of the contractor's Change Board approves or disapproves changes based on his evaluation of the membership's recommendations. He must establish operating procedures so that all board members receive information regarding a specific change sufficiently in advance of the meeting to allow them

to analyze it. He establishes and maintains an organization which schedules meetings, prepares agendas, minutes and makes distribution. He has had the responsibility for resolving problems as they occur in change board deliberations and to give direction for action which will contribute to their resolution. He issues directives which delineate approved changes.

Government Agency Configuration Control Board. A Government Agency Configuration Control Board (CCB) is established before the First Article Configuration Inspection (FACI) or First Article Review (FAR) takes place. It is composed of representatives from the procuring and using agency offices as required to adequately analyze proposed changes. They are appointed and changed by formal orders. Typical membership includes: a) production, b) contracting, c) materiel, d) engineering, e) logistics, f) training, g) quality control, h) value engineering and i) contractor representatives.

The function of the CCB is to analyze all ECP's or Technical Action Requests (TAR's) submitted by contractors for their impact on cost, performance, schedules, training, test equipment, logistics, depot, facilities, etc. It is not a voting board but recommends ECP or TAR disposition to the chairman.

Engineering Change Proposal (ECP) or Technical Action Request (TAR). The ECP or TAR is used by all contractors for submitting Class I changes to the baseline configuration established by the First Article Configuration Inspection (FACI) or First Article Review (FAR). They are generally submitted through the local office of the Government procurement representative. They may be initiated at the request of the Government agency, on the contractor's initiative or contractor approved sub-contractor's requests. ECP's or TAR's are prepared: a) when requested by the procuring Government agency, b) when required to correct unsafe conditions, system incompatibilities and/or design defects, and c) for changes which will significantly reduce the cost of the total system program. In the latter case they are usually designated as Value Engineering Change Proposals (VECP's).

Configuration Management Phases.

Configuration management may be explained in relation to the following acquisition phases.

a) Phase I - R & D, pre-operational period when the design of the individual end items of system equipment are being established and tested.

b) Phase II - Production and utilization period for each individual end item established during Phase I.

During Phase I the contractor has complete cognizance, within the broad scope of contract, over his design and development. Requirements for configuration control are not under the cognizance of the Government agency -- except by inference to prepare for Phase II. The procuring agency, however, is required to set up a Configuration Management Office which is capable of analyzing technical changes affecting specifications or interface drawings. Contractors may change their design at will in order to establish end items and the firm configuration for them.

The two phases are usually separated by an activity called the First Article Configuration Inspection (FACI) or First Article Review (FAR) which has as its prime objective the establishment of a configuration baseline. During Phase II, all Class I changes must be approved by the Government Configuration Control Board in accordance with ANA Bulletin 445A. During this phase it is important that every proposed change be given complete interface system analysis including training manuals, logistics, test equipment, specifications and mating equipment. Any resulting incompatibilities must be coordinated with all interfacing activities and fixed. The cost of making changes during this period increases as the phase ages because changes increasingly involve modification kits, installation instructions, scrap parts, re-tooling, rework parts, re-identification, re-testing, specification revisions, field testing, re-inspection, transportation charges, delays to system activation schedule, validation procedures, down time, and coordination of activities.

The utilization portion of Phase II is when the system as delivered, installed, tested and accepted by the Government agency performs its intended functions throughout its life span. Changes in this phase are usually the result of failure reports, reducing operation or maintenance costs. The cost of incorporating changes is now at its maximum.

DATA MANAGEMENT

It has been estimated that 40-60 cents of every dollar spent on the development of major weapon systems has been expended for data and documentation in all its forms. This indicates that as much or more is being spent for data than the total of all other expenses. The expense involved in the development and control of data is only part of the cost picture. Of greater importance are the costs that result from incorrect or inadequate data. When data are deficient in any of several ways; for example, if they are not complete, clear and understandable, programs can be seriously affected.

Types.

Many different types of data, in many forms, are used to accomplish technical and administrative communications. Table 6-1 lists a few of the major types of data. These primarily represent technical data requirements associated with military and space programs where large numbers of facilities, equipments, and personnel are involved. Only a few of the administrative types that are commonly connected with a major engineering effort are listed.

Table 6-2 illustrates some of the more common forms of data. Particularly important today are those forms of data that can be prepared or controlled by automation. By applying automatic machine and computer processes, large bulks of data can be handled and produced faster, more accurately, and usually at less expense. This subject will be discussed later as it pertains to the cost effectiveness of particular data requirements.

Areas of Concern.

Some of the more significant factors which contribute most heavily to the excessive costs in many data programs are:

a) Non-essential data are generated.

b) Source data from one program which may be applicable to other programs are not made readily available.

c) Many duplicative data efforts exist.

d) Data are often inadequate or incomplete for the purpose intended.

e) Unnecessary details are included.

Table 6-1. Typical Data Requirements for System Development and Support Programs.

Study Reports
Performance Specifications
Functional Specifications
Facilities Specifications
Program Data Handling Plan
Design Criteria
Design Discipline Documents
Qualitative and Quantitative Personnel Requirements Information
Design Requirements Documents
Design and Reports
Design Data Book
Interface Control Drawings
Engineering Drawings and Associated Lists
Interchangeability-Replaceability Working Lists
Manufacturing Records
Reliability Data
Failure and Consumption Data
Provisioning Data
Logistics Data Operational and Maintenance Records
Technical Data Sheets
Item Identification Sheets
Calibration Requirements Summaries
Master Allocation Schedules and Total Equipment Requirements Lists
Airborne Weight and Balance Data
Packaging Specifications
Operational Data Summary
End Item Specifications
Finish Specifications
Specification Master Index
Equipment Milestone Schedules
Environmental Data
Electro-Interference Control Data
Electrical Power Data
Configuration Identification and Control Data
Quality Control Requirements and Procedures

Acceptance Test Requirements and Procedures
Qualification Test Procedures
Acceptance Test Reports
Qualification Test Reports
General Test Plan
Test Directives (General)
Test Directives (Detail)
Test Requirements Document
Test Reports
Master Indexes of Support Information
Test Program Model
Test Milestones
System Integration and Test Plan
Test Program Logistics Plan
Test Program Drawings
Test Program Master Equipment List
Facility Assembly and Equipment Installation Drawings
Assembly and Checkout Plan
Assembly and Checkout Procedural Support Information
Assembly and Checkout Equipment List
Health and Safety Data
Spares Inventory
Program Requirements Document
Program Support Plan
Program Operations Directives
Test Operations Plan
Program Master Schedules
Technical Manuals
Inspection Work Cards
Checklists
Sequence Charts
Film Reports
Status and Progress Reports
Plans and Programs
Contractual Documentation
Cost Accounting Reports

f) Lack of controls do not assure effective use of available data.

g) Inefficient methods of developing, controlling, and updating data exist.

h) Data cost visibility is inadequate.

Table 6-2. Common Forms of Data

BOOKS AND MANUALS
DOCUMENTS AND REPORTS
DRAWINGS AND LISTS
LETTERS, MEMORANDUMS, BULLETINS
NOTES
CARDS, PLACARDS, SCROLLS AND CHARTS
AUDIO AND VISUAL AIDS
TWX'S

Causes of Deficient Data.

A general lack of knowledge and concern toward data problems has been the principal cause of the inadequacies that characterize many data programs. When any facet lacks attention, the problems multiply. This effect is more pronounced with respect to data because so many areas in defense programs depend upon data. The number of qualified data specialists to properly implement and control the data programs is not sufficient to meet the increasing requirements. Another major cause is the pace of today's highly competitive procurement programs. The concurrency concept, which has been applied to many military programs, calls for the simultaneous development of the constituents of a weapon system rather than a successive development of prime parts. The ensuing scheduling places major constraints upon data development.

The inability to obtain accurate cost figures on most data has also contributed to data problems. Only in rare instances have there been accurate accountings of actual data expenditures. Comprehensive accounting has not been obtained in many instances because of the general lack of knowledge of what actually constitutes data research and preparation. In some instances the costs of basic engineering, such as the research that is

performed to establish means of maintainability, are erroneously charged against data. In other cases the work of developing data is considered to be part of the engineering effort and only the editing and printing are charged to data. There are many other variations in handling data costs that do not clearly portray the true expense. Hence, data cost figures are frequently unrealistic.

A test bench for one missile system was acquired in which the data costs were completely separated. In this particular case, engineering and manufacturing costs for eight test benches were established at $40,000 ($5,000 per bench). The complete logistics data to support the program were found to cost approximately $100,000, two and one-half times as much as the hardware costs. If the costs of only producing the technical manuals had been charged against data, with all other data costs being absorbed in the hardware development, the ratio would have been almost exactly reversed.

Inadequate methods are used in many cases to develop and handle data. There are many areas where automation and other recent techniques will create data economies.

Data Management Approach.

At the onset of any new program, a completely fresh outlook can effect cost avoidances. The planned program can be viewed with the idea of ruling out all unnecessary requirements, establishing efficient methods, and through constant evaluation, correcting costly malpractices before they are actually started. Steps that will help to improve the value of many areas of data are:

a) Establish a data management organizational unit.

b) Develop a data program plan.

c) Identify total data requirements systematically.

d) Develop flow diagrams to show how data are to be generated, controlled, and updated.

e) Assure that proper specifications and criteria are applied to each type of data.

f) Establish standards, guides, and operating procedures for the effective development of each type of data.

g) Establish adequate data production controls.

h) Establish adequate data quality assurance controls.

i) Establish means of centrally controlling data requirements; generation and release.

j) Establish positive feedback that identifies the status of each data requirement.

k) Establish means of assuring proper dissemination of data.

l) Establish means of monitoring conformance to data program plans, standards, procedures, and directives.

m) Establish means of measuring data cost effectiveness.

n) Assure proper adaptations of advanced data production techniques such as automated equipment.

Data Program Areas of Opportunity.

Requirements Analyses. One of the most important of the newer tools to aid in system development is the systems requirements analysis. This process, as discussed earlier in this chapter, identifies total data needs for a new program. The analysis documentation was originally introduced to aid in the process of systems engineering through the demands of such military specifications as MIL-W-9411 and MIL-D-9412. These specifications call for an orderly and comprehensive identification of all the items in a weapon system.

Data that are developed from the SRA provide the basis for its technical definition. They relate all development factors and provide for proper dissemination among those who need the data to assure compatible and mating constituents in many support areas.

Engineering Drawings and Associated Lists. These data are used to define designs and permit fabrication. Great amounts of these data are inadequate and many are developed unnecessarily; many drawings and data lists that could contribute valuable services are never prepared.

The engineering drawing program can be considered to be a continuation of the requirements analysis program. The analysis data first indicate a complete conceptual design. After approval, the engineering drawing data indicate the actual design. To be accurate and comprehensive, the

data must totally reflect all details of the requirements analysis, and clearly indicate all the design factors that are needed. At the same time, for cost effectiveness, it is also important that proper controls be applied to assure that only the data that are actually needed will be supplied.

Effective use of automated data processing techniques can usually effect considerable cost reductions in the listing of parts and materials for engineering drawings. The data in these listings are also needed to support a number of other requirements such as those for procurement, schedules, configuration management and logistics. Special attention should be given to the many data processing techniques that are avilable in automated systems. With proper application of these techniques, the designer can provide simple handwritten lists of parts and material applicable to each of his drawings. The lists can then be incorporated in an automatic data handling, storage, and retrieval system. The system can be programmed to provide automated printouts for all of the various documents that use the lists as source information. First, associated data lists for attachment to the basic drawings are created. Thereafter, programming should provide for automated printouts of the other related data requirements to supply the other needs of the other organizational elements as discussed above.

Data that are often missing in the engineering drawing program are also cause for cost effectiveness concern. For example, theory information that describes how the equipment performs its functions is typically lacking. This theory is almost always needed to train personnel and to support test and trouble analysis. Facts concerning the required operation and maintenance sequences that must be accomplished by personnel are also commonly missing in the engineering drawing data. As a result, this information must be derived at much higher cost through secondary analysis or by interrogating the designers. Errors and inefficiencies are by-products of both of these approaches. In the first instance, the secondary analysis requires extensive research to determine facts that the designer already knew. Errors are also introduced due to misinterpretations of design intent. In the second instance, memory lapses produce errors and, in some cases, the designer may no longer be available when the information is sought.

In many instances, drawings show excessive data that are really not needed. For example, details on assembly and subassembly views are often redundant and always expensive. Details of individual parts, already shown on the part's detail drawings are often repeated on the assembly drawings which show the parts joined together. The problem is multiplied when the same detail on each of the subassemblies is repeated when they are shown joined in assemblies.

A common unnecessary expense is incurred by requiring drawings and related data for R & D programs to be prepared to rigid specifications. Applying such specification requirements usually results in sharply increased costs above those for informal sketches that will usually suffice. Only in instances where the commodity being designed can be reasonably assured to go into a production phase should the specifications be applied. Similarly, the expense of creating drawings to meet military specifications for commercial items purchased as parts of military systems can also be avoided where it can be shown that the original paper work is clear, legible, and contains all of the essential information.

Further opportunity occurs in unnecessary rework of engineering drawings to meet the documentation needs of other facets of the same program or other programs. This redrawing is frequently done to comply with more stringent specifications. For example, the type size, spacing, and line weight requirements for schematic drawings in a technical manual often require the original engineering schematics to be completely redrawn.

Another inefficiency may occur when drawings are microfilmed to preserve them and to reduce storage space. In many cases the process is automatically applied to all drawings whether or not it is really needed. Where single source procurement is likely, storage of the original drawings would suffice and the additional cost of microfilming is not justified.

<u>Personnel Requirements and Training Programs.</u> Initially, the requirements for personnel manning are normally established through the systems requirements analysis data. Thereafter, as the system is further developed, more information is added until the personnel and training requirements identification is complete. Ideally, as the personnel information is derived, it should be stored in an automated data bank. When this is done,

various categories of personnel requirements can be summarized and tabulated in whatever formats are needed at relatively small costs. This, of course, implies that proper data programming has already been established in the pre-planning stage.

Lack of adequate training data is often one of the most costly areas of concern in a development program. Inadequacies in this area are sure to develop if training requirements are not identified in the same systematic manner as the operational hardware. For example, when operational technical manuals are not coordinated with the training program, operational data may be at odds with the training material. Thereafter, when personnel receive the operational support data they need to perform their duties, they are unable to relate the unfamiliar procedures with their training. An integrated data program that will properly support personnel selection and training is needed for cost effective program development.

Test. Many data of test programs are not cost effective; considerable amounts of unnecessary information are provided. For example, nonessential background details and obvious conditions are described in many test documents. Other losses are incurred when the data are not clear and failures result from misunderstandings. Dollars are also expended unnecessarily on test data that may be rarely, if ever, used. For example, in some cases, after one or two tests have been conducted, the data are no longer needed. Such tests can often be accomplished with only minimal data and verbal instructions. However, because a given specification is sometimes universally applied to all test data, the data used for only a few applications are often prepared in the same manner as data that are to be used throughout an extensive test program.

Test documentation bearing meaningful data is frequently generated but may not be used properly, or not used at all. In every instance it should be assured that test result information is processed back through the design activities.

Procurement. Vast quantities of data are prepared in support of procurement. The most common contributors to excessive data costs in this arise in processes that are used to list the parts to be procured. Too often the work of preparing procurement parts lists from engineering drawing and associated lists is a duplicated effort of other documentation development

of other areas. As previously pointed out, if automated processes are used for initial storage, the parts data listing printouts can be obtained at any time at little more than the cost of machine time. Hence, in order to avoid duplication, the preparation of procurement data should be coordinated with that of data for engineering drawings and configuration control.

Site Activation and Operations. The installation and checkout of large systems, commonly referred to as site activation, requires extensive amounts of data. Other data are needed to support the actual operations when the systems are put in use. Requirements for both should be identified along with other system elements by the systems requirements analysis.

Costly duplication normally occurs between the development of site activation data and the preparation of operational technical manuals. When the requirements of both types of data are not considered jointly (since they are often prepared independently by different activities) duplicative sets of data may be developed. By coordinating the operational requirements analysis, which is usually derived first, with the follow-on site activation requirements analysis, the redundant efforts that would result in duplicate data can be eliminated. The programming can be arranged so that only one set of information is developed that will fit all of the requirements.

The high cost of operational technical manual programs has been the subject of a number of Federal boards of inquiry. In addition to the high costs that have been incurred in past programs, some single program expenditures were in excess of fifty million dollars; it was also found that the data were not entirely adequate. And, in other cases, investigations showed that there was lack of control in data selection and development. Inadequate controls resulted in unnecessary procurement and contributed to the overexpenditures. The proofing methods used on the data were often ineffective because equipment and personnel were not made available at the proper times or places. Poor coordination resulted in loss of configuration control and the manuals could not be matched with the equipment after the system had been turned over for use.

The lack of appropriate specifications has also contributed to waste in technical manual programs. Many of the specifications governing preparation and content of technical documentation require useless information to be prepared. In other instances, certain rules in the specifications cause

data to be prepared to formats that are much too elaborate for the purpose intended. Even more important is the fact that a full set of compatible specifications that will assure proper development of a completely comprehensive and coordinated set of data at minimum cost is seldom available. Only through the adaptation of numerous exhibits, deviations lists, and supplementary instructions has it been possible to avoid major difficulties. This has not been accomplished without significant increases in program costs.

Recycle and Overhaul. In many programs the data needed to support equipment recycle for refurbishment and overhaul have been neither appropriate nor cost effective. Great quantities of formal manuals have been developed for depot support that were never used. Many manuals that have been used were found lacking in many respects, particularly in timeliness. More recently, informal manuals have been prepared by inexpensive processes. Contractor manufacturing data have also been used in lieu of manuals in order to reduce costs and to simplify the processes of preparation and updating. However, although costs are reduced with these methods, the data must be delivered in time to meet program needs.

It has recently been determined that the information developed by contractors to support their manufacturing and test operations can almost always be used to support depot activities. It is logical that the information used to create and proof the equipment should also serve to support its refurbishment and overhaul. In many instances, of course, supplementary data are required to meet special requirements of depot operations. These data should be developed in a very informal and low-cost manner on a short-time basis.

Administrative Data. The data required to support program management and administration constitute one of its largest areas of expense. These data requirements need to specify only the essential requirements and all essential requirements need to be obtained most efficiently. Accounting records, production control data, program control status charts, quality control data, reliability reporting information are examples of these data.

Generating and controlling the proper types of forms is an area of administration data that will provide cost reduction potential. New forms are usually being added continuously and old ones require updating or

cancellation. Management forms are, of course, valuable tools to standardize the collection and presentation of certain types of information. Hundreds of forms are often needed on some programs, and many of them are allowed to exist long after they have outlived their usefulness. Regular paperwork reviews can often produce economies merely by eliminating or revising outmoded forms.

PERT AND PERT/COST

PERT, an acronym derived from Program Evaluation and Review Technique, is a planning and analysis tool. It is applicable to any situation which can be expressed as an interconnected series of tasks which proceed from an identified starting point to a known conclusion and which do not involve feedback between completed tasks. A flow diagram is used to portray the interdependent sequential activities required to proceed from start to completion. The two major constraints upon any project are schedules and costs. PERT deals explicitly with time as a schedule consideration; cost considerations can be derived from the time data. PERT/Cost is an extension that explicitly deals with time and cost considerations. Both can provide data inputs to value engineering decisions.

Work Breakdown Structure.

The first step is to identify the project objectives. They are usually specified in terms of deliverable end items. Each end item is then divided into its component parts. This process constitutes a work breakdown structure. Such a structure serves as the framework for planning and controlling the project. The project is divided into successively lower levels until the end item subdivisions become manageable units for control purposes. The end item subdivisions at the lowest level in the breakdown structure are then divided into work packages, i.e., the tasks to be accomplished (design, fabrication, test, documentation, etc.). It is upon the basis of these units of work to be accomplished that a PERT system is developed and maintained as a program control factor.

An example of a work breakdown structure is shown in figure 6-3. A communication satellite development program is broken down into its deliverable end items. One of these, the battery pack is further separated into two groups of work packages: a) the battery pack itself and, b) its

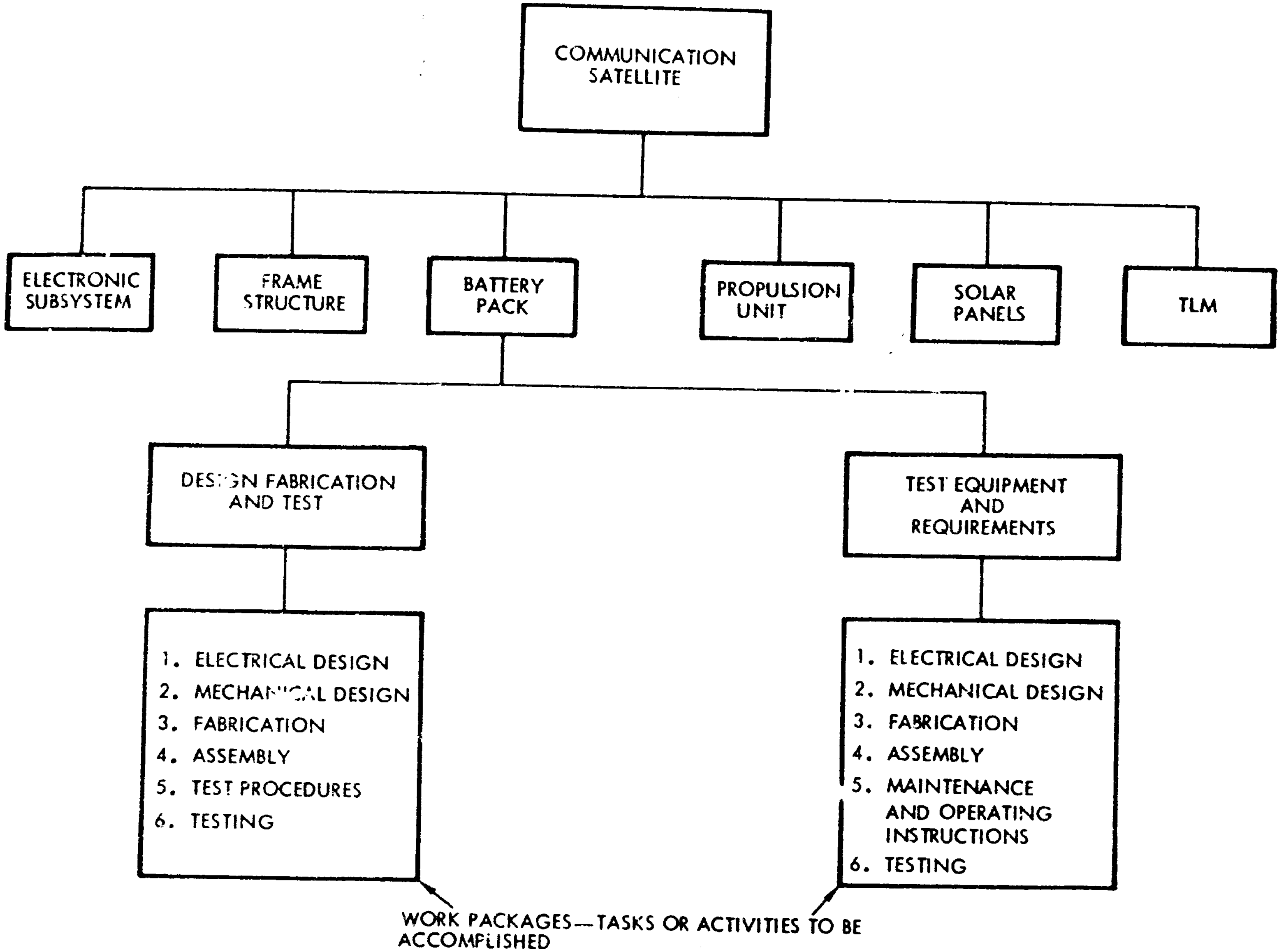


Figure 6-3. Simplified Work Breakdown Structure Example

special test equipment and testing requirements. These, and the other work packages for the program are integrated and presented by means of a PERT network.

Network Construction.

The PERT network is a flow diagram of the work packages and milestones which must be accomplished to reach the program objectives. The network illustrates the planned sequence and interdependencies of the individual tasks from project start to project completion.

Figure 6-4 is a condensed and stylized simplification of a network for the design, fabrication and testing of the battery pack portion of the communication satellite shown in Figures 6-3. The numbered circles 01 through 12 are called events. They are synonomous with milestones. The lettered arrows (a through n) leading from a preceding event to a succeeding event represent the activities, or tasks, that must be performed to proceed from event to event.

a) Event 01 signifies the start of this project and event 12 is its completion.

b) The occurrence of any event requires the completion of all previous activities. For example, event 08 cannot occur until activities a, b, c, f and g are finished.

c) An activity cannot be started until its preceding event has occurred. For example, activity m cannot begin until event 10 has occurred.

d) To reach event 12, the end of the project, all preceding activities (a through n) must be completed.

Time Estimates.

After the network is constructed the time to perform each activity is estimated, usually in weeks. As in any estimate there is an element of uncertainty. It is possible to operate on this uncertainty by obtaining estimates for each activity: a most likely time estimate (m), an optimistic time estimate (a), and a pessimistic time estimate (b). An expected elapsed activity time (te) that has a .50 probability of being the actual time is calculated by:

$$t_e = \frac{a + 4m + b}{6} \qquad (6\text{-}1)$$

The expected elapsed time is an adjustment to reflect the possibilities of underrun or overrun. The time estimates are made by those who will

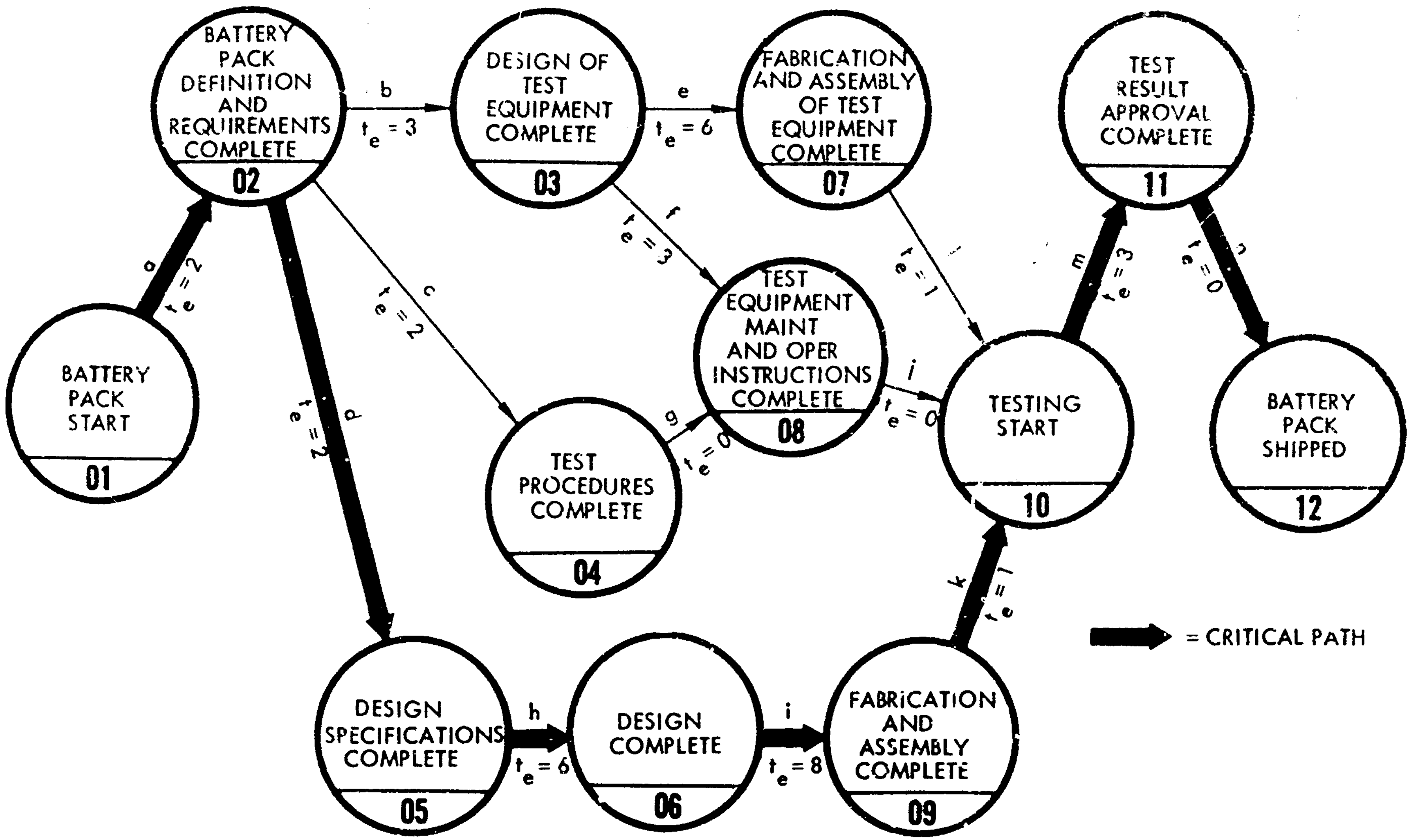


Figure 6-4. Condensed and Stylized PERT Network for a Battery Pack

perform the task. The activity time estimates are not based on the time that is available, but rather what is best judged to be the time to do the job as presently planned. Some PERT operations use only one time estimate.

Earliest Expected Date.

The earliest date at which an event can be expected to occur is called the earliest expected date, T_E. The T_E value for a given event is calculated by totalling the t_e's for all activities on the longest path from the beginning of the program to that event.

The t_e for each activity is in weeks on Figure 6-3. For example, the expected time for activity b to proceed from event 02 to event 03 is 3 weeks. The earliest expected date (T_E) for the occurrence of event 08 will depend upon the serial performance of activities a, b and f, and upon serial performance of a, c and g. Even though task g will be completed at week 4, event 08 cannot occur then because all preceding events have not occurred. The T_E for event 08 is week 8 (2 + 3 + 3).

Latest Allowable Date.

The latest allowable date for an event is related to the directed delivery date for the end item. The date that each event in the network must occur in order to meet the final scheduled delivery date is called its latest allowable date (T_L). For example, assume that the required delivery date of the battery pack project illustrated by the network of Figure 6-3 is 18 weeks after project start. Then 18 weeks is the latest allowable date for event 12 (assuming local delivery). To calculate the latest allowable date for each event proceed backwards through the network from the last event and subtract the expected elapsed time (t_e) for each activity from the total allowable time and use the smallest absolute value for the T_L of each event. For example, T_L for event 03 is 8 weeks, since 10 weeks must be left after event 03 occurs for activities e, l, m and n to be performed.

Slack.

The difference between the latest allowable date and the earliest expected date for each event is called slack.

$$\text{Slack} = T_L - T_E \tag{6-2}$$

Slack may be positive, zero or negative. Zero slack indicates an event is expected to occur exactly on schedule. Negative slack values can be interpreted as the time (usually in weeks) that an event is presently anticipated to be behind schedule. Positive slack indicates the number of weeks that an event may be delayed and will still meet program schedule. Positive slack may indicate that one or more of the precedent activities have excess resources.

Critical Path.

There are usually many activity paths to be traversed between project start and completion. The longest path through a PERT network project is called the critical path. For example, the total time required to complete all activities in figure 6-3 from event 01 through event 12 is 22 weeks via 01 - 02 - 05 - 06 - 09 - 10 - 11 - 12. It is the path of greatest negative (or least positive) slack. All other paths through the network reflect a total expected elapsed time less than 22 weeks.

An earliest expected date of 22 weeks for event 12 means a delay in meeting the directed delivery date of 18 weeks. Manpower or funds must be added to the project, transferred from activities with positive slack to activities on the critical path, or the plan for performing the project revised and re-analyzed.

PERT/Cost.

A PERT/Cost system accumulates, analyzes and presents the dollar cost and the time considerations of the program tasks. A charge number is used to identify the costs charged to each work package. A work package consists of one or more significant activities. The work package couples to the cost accounting system through the charge number and to the PERT network through the beginning and ending event numbers of activities in the package. Cost data are initially estimated for each work package as the initial network is prepared. The cost estimates are updated with the time estimates as the project proceeds. Actual costs are accumulated as they are incurred.

Figure 6-5 shows a simplified summary PERT/Cost network for the design, fabrication and test portion of the battery pack for the communication satellite diagrammed in Figure 6-3. The estimated costs equivalent to

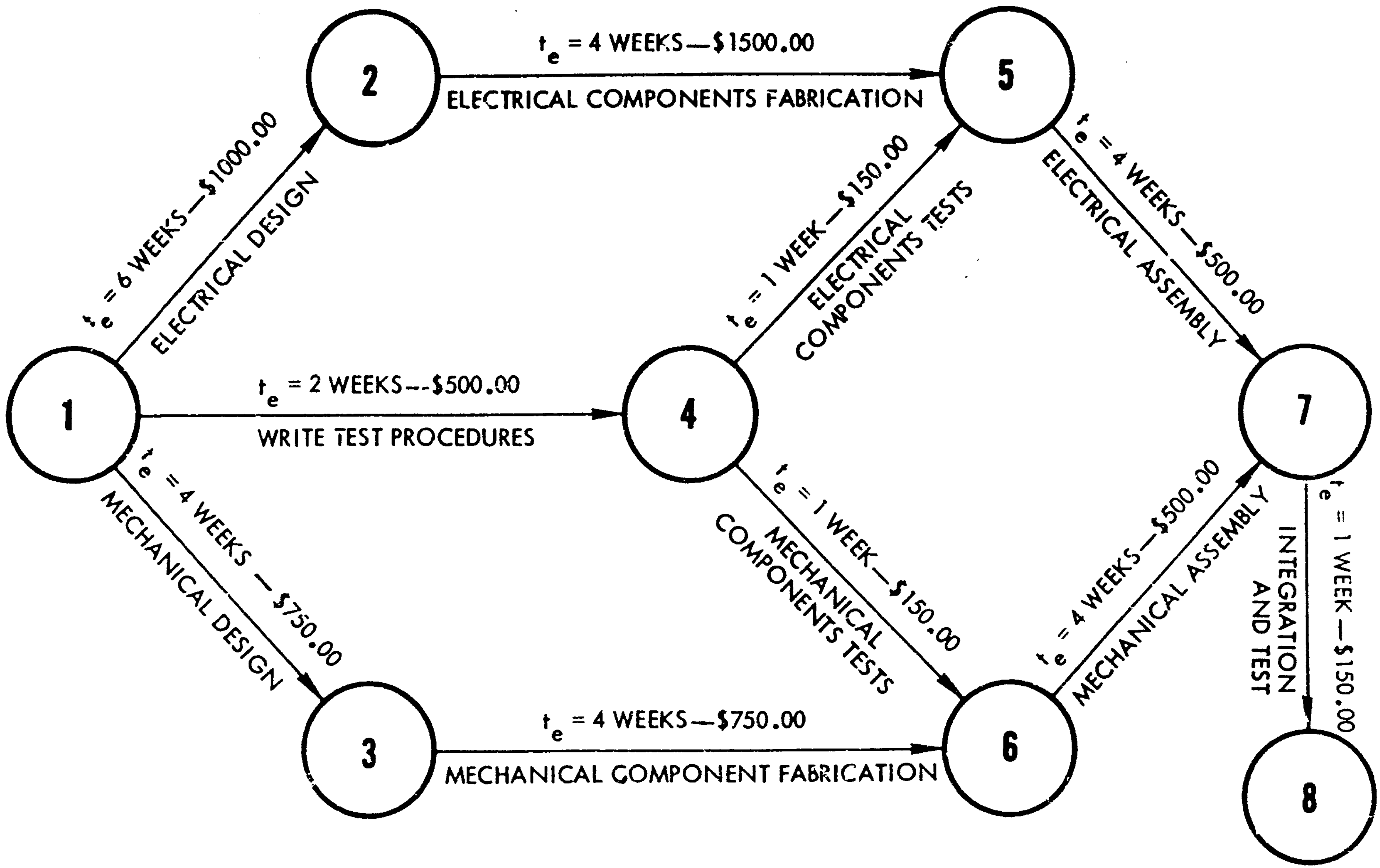


Figure 6-5. Simplified Summary PERT/Cost Network for the Design, Fabrication, and Test Work Packages of the Battery Pack

each activity are shown with the expected elapsed times. In actual practice the event nomenclature would be included and the activities would be indicated by their charge number.

Analysis and Reports.

PERT provides program analyses updated on a regular periodic basis (monthly or bi-monthly) which usually show: a) completed activities, b) expected elapsed times for incomplete activities, c) earliest expected dates for events that have not occurred, d) their slack, and e) the location of the critical path.

PERT/Cost can supplement these data with: a) actual expenditures to date, b) budget requirements for future months, c) a projection of manpower requirements by months, d) the time and cost status of the accounts within each unit manager's area of responsibility, and e) an integration of time and cost summarized for each level of program management.

Interfaces with Value Engineering.

The value engineering effort may make effective use of either the PERT or PERT/Cost systems if they are being used on a particular procurement. Even when not used on the entire program the PERT technique may be informally used by the value engineering personnel for planning and controlling the value program tasks. Networks of value programs will usually contain less than 50 events. These may be manually calculated; a computer is not needed.

Cost Reduction of Overruns. The critical path isolates the tasks that would benefit from premium time expenditures and the exact amount of time improvement that needs to be bought. It may be possible to transfer manpower or other resources from positive slack activities to one or more on the critical path. Event 07 in Figure 6-3 has positive slack of +3. Activity e involves the fabrication and assembly of test equipment. Activity i (on the critical path) involves the fabrication and assembly of the battery pack. Its succeeding event, 09, has slack of -4. If these two functions are planned to be performed in the same facility area, it may be possible to transfer manpower or resources easily from e to i. Activity e apparently can be delayed 3 weeks. If the transfer of resources is quantitatively equivalent, it will raise the T_E of event 07 from 11 to 14 weeks without jeopardizing

its latest allowable date. By this transfer the T_E of event 09, 10, 11 and 12 will be reduced to 17 weeks, 1 week less than the directed time to complete the project. Similar procedure may be used to reduce other tasks to obtain planning which concurs with required schedules. Without these data, the probability is higher that incorrect expenditures will be made for tasks which do not really need shortening and resources may be transferred from areas that may then become overruns themselves.

Over-emphasis on the slack path concept must be avoided. Calculations of critical and slack paths in PERT consider only the constraints in the program which are represented on the network. These constraints reflect the technical dependencies and interrelationships which are inherent in the work to be performed. In addition to these constraints, factors such as the availability of particular resources and facilities in specific calendar time periods are major considerations in identifying the true critical and slack paths of the program. Because of this, there is a danger in thinking that the critical and slack calculations derived from a PERT network will automatically indicate the true time available for moving activities either backward or forward in calendar time periods. Before a realistic slack figure can be derived for a program, it is important to review not only the technical constraints in the program itself, but also the flexibility available in scheduling particular resources and facilities at varying time periods.

Project Selection. The PERT network with its associated expected and schedule data, enhanced by cost aspects when available from PERT/Cost, will assist in project selection decisions. Networks concisely show what product components and processing activities are expected to require the greatest time and cost relative to all others in the project. This isolates the highest cost areas. These should be among the first ones examined as possible value projects in accordance with the criteria mentioned in Chapter 1.

The PERT data will also portray the expected and directed schedule for accomplishing these components and their associated activities. A schedule for the value study of selected projects may then be prepared which is coherent with the overall program planning.

Changes in the project network may result from value engineering effort. As value engineering proposals are likely to alter the hardware

designs, they may also alter the type, sequence, time and cost of the activities whose purpose is to produce the design. However, as time passes PERT networks are modified and updated in accordance with restrictions and progress actually experienced with the project. Thus, Value Engineering efforts should be integrated with the information system supporting the PERT/Cost effort.

SPECIFICATIONS AND STANDARDS

DoD Standardization Manual M-205 defines a specification as "... a clear and accurate description of the technical requirements for a material, a product, or service, including the procedures by which it can be determined that the requirements have been met." Specifications are the common communication base for the procurement of DoD items. Their existence precedes hardware and they frequently remain operational after hardware obsolescence. Specifications may be viewed as summary presentations of the main factors that cause defense inventory items to cost more or less and, hence, cause better or poorer value.

Specification Types.

Industry and government have developed so many adjectives to describe specific applications of specifications that it is very difficult to discuss specifications in general. The following adjectives are some of those in common use today:

FUNCTION ORIENTED	PRODUCT ORIENTED
Design Specification	Model Specification
Detail Specification	Subsystem Specification
Performance Specification	Product Specification
Manufacturing Specification	Part Specification
Test Specification	Component Specification
Acceptance Specification	Commodity Specification
	Equipment Specification
	Material Specification
	Process Specification
	Finish Specification

Military specification MIL-S 6644A and Standardization Manual M-200A have standardized specification format into a six section arrangement as follows:

Section 1: Scope. This section contains the extent of applicability (air-borne, missile, ship board) of a product or service and when necessary, specific detailed classifications by grades, such as degrees of allowable contamination, e.g., Type I, Type II.

Section 2: Applicable Documents. This section lists the documents referenced in other sections and incorporated into the Specification.

Section 3: Requirements. The essential requirements and description applying to performance, design, reliability, etc., covered by the specification are stated in this section. These requirements and descriptions refer to the character or quality of the service materials, formula, design, construction, performance, reliability, transportability and product characteristics, chemical, electrical, and physical requirement, dimension, weight, color, name plates, product marking, and workmanship

Section 4: Quality Assurance Provisions. Section 4 of the specification includes complete and detailed information concerning sampling, examination, and tests that must be performed in order to establish that the item or service to be offered for acceptance conforms to the requirements of sections 3 and 5 of the specification.

Section 5: Preparation for Delivery. All requirements applicable to the preservation, packaging, and packing of the item and applicable to the marking of the shipping container are specified in Section 5. These requirements should specify only that level of preparation necessary to assure that the item survives the handling, shipping, and storage conditions and arrives at its destination in acceptable condition.

Section 6: Notes. Section 6 contains information of a general explanatory nature and should not contain any statement that could be construed as binding on the buyer or seller. Typical information included is: a) intended use, b) ordering data, and c) definitions.

Section 3 of a specification is broad enough to include the functionally oriented types of specifications listed above, such as Engineering, Design, Detail, Performance and Manufacturing. Section 4 contains the element of test and acceptance. When procurement, purchase or contract is used as an adjective to describe a specification, it means that the buyer or seller

has satisfied himself that the contents of the specification which describe a product are sufficient for contractual procurement.

The descriptive adjective of the individual types are not sufficient in themselves to convey the intent or use of a specification. For example, a Part Specification may contain design, performance and test requirements and be used to procure the item.

Performance Specification.

These are specifications which express requirements in the form of output, function, or operation of equipment, with whatever limiting dimensions that are needed for mounting and configuration, leaving the details of design fabrication to the producer.

Design Specification.

The design specification contains the definitive data necessary to generate the item. This will normally include a description of material, composition, physical and chemical properties, weight, size, dimensions and performance. Design specifications establish the exact features of design to be used in the manufacture of a product. When drawings are available to describe the design, design specifications are written to include the details on workmanship, interchangeability, and to detail or reference other specifications covering finish, preservation, packing and testing. This type of specification is written when other than over-all interchangeability is affected, and it is necessary to specify the details of the design, such as interchangeability.

Procurement Specification.

Either performance or design specifications may be used by industry or by the DoD to procure an item. (i.e., as a procurement specification) If it is desirable to procure a commodity in which all the detail parts are interchangeable, a specification containing detail design requirements should be used. However, if an equipment with a stipulated performance is desired without regard to its internal construction, a specification written in terms of performance features should be used. (i.e., a performance specification)

Use of Specifications.

Specifications assure the ability to measure reproducibility of results. An engineering drawing does not give all of the information the shop needs to manufacture the part. A drawing which is complete by all known drafting standards may still contain points of interpretation. If the materials and processes necessary for the completion of the part are not covered by specifications, then such qualities and characteristics as strength, corrosion resistance or appearance will vary from day to day, from shop to shop, and between workers.

What makes the specification so indispensable is the fact that it is impossible to manufacture two components identical in all respects. Practical engineering requirements call for compromise and approximation. The purpose of a specification is to define the parameters of these approximations and thereby limit the variations. By describing a process or a component and by limiting the variability of its characteristics, a specification controls the process or product. It permits prediction and constancy of results in the accepted items.

The specification is useful for exercising control over the system, from the earliest stages of design up to the definition and control of configurations. As a management tool, the specification can provide management with an evaluation and reflection of the development of the system as a yardstick for reporting status, compliance, and future goals.

In this respect, specifications can no longer be thought of as tools for procurement alone. The specifications likewise should not be thought of as a research and development document, but should be looked upon as a dynamic document with controlled growth.

Preparation.

Specifications have some aspects of legal codes and military orders. They must be worded to exclude the possibility of misinterpretation and confusion. The specification is a formal document and should approach the precision of a mathematical definition. Precision in the preparation of engineering specifications is especially important because they set criteria for performance and obligation for a fee. It clearly defines a

requirement and offers a method of measurement to determine the contractual degree of compliance.

Proper specification preparation is necessary in order to assure that the product desired is actually reflected in unambiguous language. The following rules will help in obtaining these goals:

a) Avoid writing a new specification whenever possible. Try to adopt one already in existence. This practice can save time and money.

b) Amend an available specification when it cannot be used as is. If, for example, the existing specification is too specific where it should be general, and general where it should be specific, the specification should be amended as necessary and all suitable paragraphs copied as is. It is good practice to mention the basic specification in the "Applicable Documents" section of the company specification with the following note: "The following specification, No. XXXX, is a part of this specification to the extent specified herein."

c) For each requirement of the specification, indicate a corresponding test procedure, cross referenced whenever practical. For example:

Requirement	Requirement Paragraph	Test Method Paragraph
Temperature Cycling	3.8	4.8
Plating Thickness	3.9	4.10
Moisture Resistance	3.10	4.12

d) Avoid devising test methods for internal company use only. Use the standards developed by ASTM, government, or other organisations as much as possible.

e) Assign a realistic tolerance to each requirement or characteristic expressed as a numerical value. If the requirement is merely stated as 10 w, 100,000 psi, or 100 F., it does not tell what to do if the measured values are 10 1/2 w, 99,999 psi, or 99 or 101 F. For example, pressure tolerances may be expressed in any of the following ways:

100,000 psi + 1000 psi, or 100,000 psi max, or

100,000 psi min to the nearest 100 psi, or 100,000 psi min

Tolerance to the nearest 100 psi means that 99,950 and all values over 99,950 are rounded off to 100,000 psi and accepted. All values less than 99,950 are rounded off to 99,900 psi and rejected.

f) Specify only those requirements necessary to do the job. Know the cost effects of each requirement and tolerance in terms of the characteristics of the product to be controlled and the degree of control.

g) Specify a sampling plan, indicating how test specimens will be selected and inspected. For information on sampling procedure, the following publications are recommended:

MIL-STD-105	- Sampling Procedures and Tables for Inspection by Attributes
MIL-E-5272	- Environmental Testing, Aeronautical and Associated Equipment
MIL-STD-414	- Sampling Procedures and Tables for Inspection by Variable for Percent Defective
MIL-STD-109	- Inspection Terms and Definitions
ASTM	- Manual on Quality Control of Materials

h) Be specific and aim for simplicity and clarity of expression. Specifications are read by personnel of varied background, education and skill level. They must be unambiguous to avoid multiple interpretations.

i) Never rely on catalog information alone when writing a specification. Component requirements are not always clearly spelled out in such literature and often require amplification.

j) When non-standard or little known terms are used, define them. For example:

"Room temperature shall be 75 ± 12F"

"Sea level shall be from 0 to 10,000 ft."

<u>Standards.</u>

A specification reflects current or desired practices and may be narrow or specialized in scope and subject. A standard, on the other hand, is a specification accepted by recognized authorities as a practical and appropriate solution of a recurring requirement. The Defense Supply Agency publishes and distributes Defense Standardization Manual M200A. Its use is mandatory for all military organizations. It contains "Standardization Policies, Procedures and Instructions" for the preparation, coordination, control and use of standards, specifications and handbooks within the defense departments. This manual also contains some important definitions:

Standardization. Standardization is the process of establishing, by common agreement, engineering criteria, terms, principles, practices, materials, items, processes, equipment, parts, subassemblies and assemblies to achieve the greatest practicable uniformity of items of supply and engineering practices. Standards documents establish engineering and technical limitations and application for items, materials, processes, methods, designs and engineering practices. They limit the selection of materials, items and services in order to provide for: a) functional and physical interchangeability of parts, components, subassemblies and equipments, b) compatibility of items and equipments in their own or related systems, c) establishment of basic engineering terminology and codes, and d) limitations of the variety of end-use items which can be procured for stock and issue.

Component Standards. Component standards are documents such as MS's and NAS's which define parts that are functionally and economically preferred for usage over similar parts. To justify designation of a standard for a particular part, each of the following requirements should be considered:

a) The part must be in multiple usage or multiple products, or have such potential.

b) There must be a uniqueness of configuration, i.e., no other equivalent existing standard.

c) There must be an overall cost reduction potential.

d) Availability must be assured.

e) The part must improve interchangeability for maintenance and repair.

f) The part must improve reliability and maintainability.

g) There must be a projected reduction of spares stocking requirements.

Relationship of Standards and Specifications.

Standards function in procurement through the medium of specifications. In equipment specifications, they are used by reference to standardize on those design requirements which are essential to interchangeability, compatibility, reliability, and maintainability. Except for item feature

standards, they provide the designer with the descriptions and the data normally required for intelligent selection and application.

Physical item standards provide guidance for application in the development stages of equipment for the incorporation of proven parts and components; limitation of variety in supply for initial simplification of the supply system; or for further refinement of supply as a result of technical analysis.

Item standards disclose or describe the technical features of an item in terms of what it is and what it will do. Their use in design restricts at the source the variety of items subsequently required to be stocked in support of equipment.

As an example of the relationship of specifications to standards, a standard for self-locking nuts (MS21042) would reference the screw-thread specification MIL-S-7742 and performance specification MIL-N-25027 to insure the interchangeability of self-locking nuts produced by different manufacturers and to permit predictability of performance between manufacturer's products. The face of the standards drawing self-locking nuts (MS21042) requires the following additional applicable specifications and standards:

a) Plain cadmium plated nuts to be in accordance with Federal Spec. QQ-P-416 Type II, Class 3.

b) Surface roughness to be in accordance with MIL-STD-10

c) Nuts shall be used in accordance with limitations of MS 33588

d) Only nuts for which there are qualified products listed on QPL 25027 shall be used for design.

e) The dimensions across the wrenching flats of this standard are the subject of international standardization agreement ABC AIR STD 17/2.

Drawing Standards. A measure of control for uniformity of drawing practices is being exercised through use of MIL-D-70327, Drawings, Engineering and Associated Lists. In addition there are at least twenty-five MIL-STD (military standard) documents in support of MIL-D-70327 numbered from 1 to 34.

Index of Specifications and Standards. The DoD Index of Specifications and Standards is one of the most important and constantly used publications controlled by the Defense Supply Agency. It lists Federal and Military specifications, standards and related documents that are used by military departments, civil departments, and defense contractors. All available Federal specifications and standards are listed in the "Index of Federal Specifications, Standards and Handbooks" issued by the General Services Administration. Most of these are non-military in application.

The documents listed in the DoD Index of Specifications and Standards include:

Military Specifications (MIL-A-XXX)
Military Standards (MIL-STD-XX) Book form, generally not hardware.
Federal Specifications (C-C-XXX) - Military Standard (MS-XXXXX) - Part standard sheet form.
Federal Standards (FED-STD-XXX)
Air Force-Navy Aeron. Standards (AN-XXX) Hardware, being replaced by MS's
Air Force-Navy Aeron. Specifications (AN-XXXX)
Air Force-Navy Aeron. Design Standards (AND-XXXXX)
Air Force-Navy Aeron. Bulletins (ANA-XXX)
Air Force Specifications (X-XXXXX)
Air Force Specification Bulletins (BU-XXX)
Military Handbooks (MIL-HDBK-XXX)
Qualified Products Lists (QPL-XX/XX)
Other Departmental Documents (GSA-XXX)

MS Standards (mostly hardware, are replacing AN's)

AN Standards (mostly hardware of the same kind as MS's - many have been cancelled, or declared inactive)

MIL-STD-143A, Order of Precedence for the Selection of Specifications and Standards. This standard is a mandatory requirement on all design activities for military equipment. It delineates preference for those standards and specifications controlled by the Defense Supply Agency which most adequately fulfill the Government's needs for function, reliability, maintainability, logistics, inventory and cost. A general grouping in preference order is:

a) MIL (Military) and FED (Federal) Specifications and Standards, then

b) NAS, AMS, ASTM, etc. (standards issued by technical societies and industry associations), then

c) Contractor issued standards.

Non-Government Controlled Specifications and Standards.

NAS (National Aerospace Standard). These are numbered sheet or drawing type standards prepared by the National Aerospace Standards Committee. These standards include hardware, shapes (extrusion), specifications, standard practices and commercial parts. They are typical of the kinds of hardware covered by MS's and AN's. These standards were initiated for needs that Government standards did not satisfy.

AMS (Aerospace Material Specifications). These are prepared by the Society of Automotive Engineers for the aerospace industry. They are material specifications with associated quality controls and processes. There are also a few hardware standards under AMS numbers.

ASTM (American Society for Testing Materials). These are primarily material specifications for the manufacturing and construction industries plus methods for chemical analysis and physical testing.

ASA (American Standards Association). ASA publishes standards and specifications related to every phase of American industry and commerce. They are generally non-military and are sponsored by most of the pertinent technical societies and industry associations.

Contractor Standards. These arise during research and development work when needs are generated which are not met by any of the previously discussed documents. This is to be expected, especially in R & D programs. It illustrates that standardization is far from a static activity. Some new standards become rapidly obsolete and many others become firmly established and more useful. Many company and vendor standards have evolved through stages to become NAS, AMS, individual service standards and finally achieve Military or Federal standard status.

SYSTEMS MANAGEMENT INTERFACES: SUMMARY

A. Systems Requirements Analysis (SRA) generates coherent subsystem criteria for design, development and specification of equipment, facilities, personnel and procedures in the early stages of system development. It determines the consequences of trades between alternate criteria by simulation studies which use an analytical model of the system programmed for computer calculation.

B. Data and documentation, in its many forms, may account for one half of the cost of weapons systems development.

C. The data area offers opportunities for cost avoidance through more intensive attention to the requirements, management, and preparation of documentation.

D. PERT and PERT /Cost networks and analyses are useful aids to identify activities for cost reduction treatment, to determine if time is available for study of a project, and the cost consequences of schedule variations.

E. Specifications are primary determinants of defense item acquisition cost.

F. The specification factors which affect cost are the requirement for the specification itself, the absolute numerical value of its specified criteria, the range of the tolerance allowed for each specified numerical value and the preceding factors for the other specifications which are made obligatory by reference.

Chapter 7: Contractual Aspects

Contractor value engineering efforts are obtained by contractual arrangements... there are several types of value engineering efforts that may be procured... the results may require contract modifications... and may affect procurement cost... DoD value engineering performance may affect present or future cost of items procured by contract... an understanding of contract principles is needed for effective application of value engineering... This Chapter presents some highlights of contract law... Government procurement... contract types... and modification procedure... The ASPR section on value engineering is examined in detail... and procurement of contractor value engineering services by separate contracts is noted.

CHAPTER 7

CONTRACTUAL ASPECTS

CONTRACT DEFINITION AND PURPOSE

Definition.

A logical point of departure is to offer an easily understood and meaningful definition of the term "contract." There is an abundance of such definitions based upon an almost limitless choice of approaches to the definition. Legal scholars and writers have been prolific in their output of contract definitions, and it appears safe to say that every court of competent jurisdiction in the United States has, at one time or another, addressed itself to the task of defining a contract. Some courts, even in declaring a contract action outside its jurisdiction, apparently have been unable to resist the challenge of perfecting the definition of a contract. Some of the definitions that are useful for this Guide are:

> A contract is a promise or a set of promises for the breach of which the law gives a remedy, or the performance of which the law in some way recognizes as a duty.
>
> An agreement between two or more persons, upon sufficient consideration, to do or not to do a particular thing.
>
> A promise, or a set of promises, to which the law attaches legal obligation.
>
> Where one party, for a sufficient consideration, offers to do or not to do a particular thing, and there must be acceptance by the other party of that offer, and this offer and acceptance must be equally binding upon both parties to the agreement, and must be to do a particular thing.

Note that some definitions are based upon the word "promise" and some are fundamentally concerned with the word "agreement." Some rely heavily for their meaning upon the words "offer," "acceptance" and "consideration."

Purpose.

Space will not permit detailed treatment of the principles and theories underlying the law of contracts. The real concern here is the function and purpose of a contract.

Corpus Juris Secundum[1] affords the following statements about the purpose of a contract:

> "Generally speaking, the purpose of a contract is to reduce to writing the conditions on which the minds of the parties have met and to fix their rights and duties with respect thereto. As otherwise stated the purpose of every contract is to bind the parties to performance and to place the risk of performance upon the promisor.
>
> The essential elements of a legal contract are generally enumerated as being: (1) Parties competent to contract. (2) A proper subject matter. (3) A legal consideration. (4) Mutuality of agreement. (5) Mutuality of obligation.... The law, not private agreement, determines the essential elements of a contract, and it is not every agreement which results in a binding, legally enforceable contract. Where a contract is affected with a public interest legislation may prescribe and limit the terms of such a contract..."

GOVERNMENT CONTRACTS

There are significant differences in contracts between private individuals or concerns and contracts between the Government and private individuals or concerns. Commercial contracts are contracts between private individuals or concerns to which the Government is not a party. Government contracts are contracts between the Federal Government and private individuals or concerns.

Sovereign Capacity.

Probably the most significant factor which differentiates Government contracts from commercial contracts is the sovereign capacity or sovereign

[1] C.J.S. Contracts, Sec. 1-545, 546

entity of the Government. Despite a statement by the United States Supreme Court in 1875 that,

> "... if [the Government] comes down from its position of sovereignty, and enters the domain of commerce, it submits itself to the same laws that govern individuals there."

it must be remembered that this sovereignty does exist -- and while it may figuratively step down to the domain of commerce; literally, in this present day, its sovereign immunity steps down with it in a shadow-like fashion.

Effect of Legislation on Government Contracts.

A recent case before the Armed Service Board of Contract Appeals (Metrig Corp., ASBCA 8455) serves to illustrate both the effect of legislation and the sovereign capacity of the Government on the contractual relationship between the Government and its contractor.

In the Metrig case, the appellant entered into a contract with the Government for construction of a housing project in Puerto Rico. The contract incorporated the provisions of the Davis-Bacon act, and was therefore subject to the minimum wage rates determined by the Secretary of Labor as the minimum prevailing wage rates in that area. On the date on which the contract was executed a Labor Department order, under the Fair Labor Standards Act, also existed which prescribed minimum wages for construction work in Puerto Rico at a rate higher than that determined under the Davis-Bacon Act. The provisions of the Fair Labor Standards Act were not formally incorporated in the contract.

The Board, in denying the appellant relief for the higher wages required under the FLSA order, held that the contractor had constructive notice of the higher prevailing wage under the FLSA, and ruled that the order under the FLSA overrode and superseded the minimum wage under the Davis-Bacon Act.

The Board further denied the contractor recovery of additional labor costs resulting from an increase in the minimum wage prescribed by Congress under the Fair Labor Standards Amendment of 1961 at a date after the date of execution of the contract and after a considerable period of the contract term had elapsed. The Board held that this increase of

the minimum rate was "an act of the Government in its sovereign rather than its contractual capacity and the Board has no authority to grant relief in such cases."

A further consideration of interest, with regard to the sovereign capacity of the Government, is that by specific contract provision most Government contracts issued through the Department of Defense excuse the contractor from the consequences of delays in contract performance occasioned by acts of the Government in its sovereign capacity. This is of interest, and importance, since it illustrates the ability of the Government, within certain limitations, to elect by specific contract provisions to be treated in its contractual rather than sovereign capacity.

Apparent Authority.

The authority of a contracting officer, in acting as an agent of the Government, is prescribed and limited by statute and its implementations. All persons are presumed to have constructive, if not actual notice of the law. They are further presumed to have actual knowledge of the Contracting Officer's scope of authority. Therefore there is no basis for a contractor's reliance on the "apparent" authority of Government Contracting Officers.

ADVERTISED AND NEGOTIATED PROCUREMENTS

In a general sense there are two classes of Government contracts: a) those resulting from an advertised procurement, and b) those resulting from a negotiated procurement. These are methods of procurement rather than contract types which will be discussed later.

Advertised Procurement.

Advertised procurement is the preferred method of awarding contracts since it affords the maximum opportunity for effective price competition. The requirement for procurement by formal advertising is stated in mandatory language. Circumstances which permit procurement by negotiation are stated as exceptions to that requirement.

The requirements for procurement through advertising are both detailed and strictly construed. Explicit instructions govern the following general requirements: a) preparation of invitations for bids, b) solicitation of bids, c) submission of bids, d) opening of bids, and e) contract award.

The type of contract to be awarded under advertised procurement is limited to firm fixed price or fixed price with escalation. Procurement action under fixed price contracts requires that the specifications and requirements of the item being procured be completely defined and susceptible to uniform interpretation.

Negotiated Procurement.

The authority for negotiated procurement exists by exception. There are seventeen permissible exceptions. Those of most likely importance for purposes of this Guide are:

a) It is determined that such action is necessary in the public interest during a national emergency declared by Congress or the President.

b) The public exigency will not permit the delay incident to advertising.

c) The purchase or contract is for property or services for which it is impracticable to obtain competition.

d) The purchase or contract is for property or services that is to be for experimental, developmental, or research work, or for making or furnishing property for experiment, test, development, or research.

e) The purchase or contract is for property or services whose procurement should not be publicly disclosed because of their character, ingredients, or components.

f) The purchase or contract is for equipment determined to be technical equipment whose standardization and the interchangeability of whose parts are necessary in the public interest and whose procurement by negotiation is necessary to assure that standardization and interchangeability.

g) The purchase or contract is for technical or special property which will require a substantial initial investment or an extended period of preparation for manufacture, and for which formal advertising and competitive bidding might require duplication of investment or preparation already made or would unduly delay the procurement of that property.

h) It is in the interest of national defense.

The procurement requirements of the negotiated procurement process are less rigid than for formal advertising. The discretionary powers of the contracting officer are increased. As an example, proposals submitted by the contractor for negotiated procurements may be opened immediately

upon receipt. Late proposals or amendments may be considered if it appears to be in the best interest of the Government. Either of these actions could void an entire procurement effort under the advertised concept.

TYPES OF CONTRACTS

The term "contract type" employed in the following discussion is used in the context of the type of compensation arrangement between the Government and the contractor as opposed to the form, structure or end purpose. In March 1962, the Armed Services Procurement Regulation (ASPR) was revised to place emphasis on motivating defense contractors to a greater assumption of risk through the recognition of a commensurate greater profit potential. This has entailed a shift from cost-plus-fixed-fee contracts to firm fixed price and to fixed price and cost reimbursement type contracts with contractor incentive provisions.

Fixed Price Contracts.

There are several types of fixed price contracts designed to facilitate proper pricing under varying circumstances. This flexibility allows maximum use of the fixed price concept in as many procurement situations as possible which can result in an equitable contractual relationship for the Government and the contractor.

Firm Fixed Price Contract. The firm fixed price contract is the type most preferred by the Government. Under this type of contract the maximum risk is placed on the contractor. At the same time, the maximum profit potential exists since the contract price is not subject to either upward or downward adjustment solely by reason of cost experience of the contractor during performance.

The firm fixed price contract is suitable for use in procurements when reasonably definite design or performance specifications are available and whenever fair and reasonable prices can be established at the outset. It is particularly suitable in the purchase of standard or modified commercial items and military items sufficiently described by specifications.

Fixed Price Contract with Escalation. The fixed price contract with escalation differs from the firm fixed price contract by providing for an upward or downward adjustment of contract price upon the occurrence of certain agreed upon contingencies which may affect the cost of performance. A

ceiling price, limiting the dollar amount of upward adjustment, is contained in this type of contract. The use of this type of contract, in most instances, is limited to a situation involving, a) a long term of contract performance, or b) unstable market or labor conditions.

Fixed Price Incentive Contracts. Fixed price incentive type contracts provide for upward or downward adjustment of the contract price by a formula based on the relationship of the negotiated final cost to an initial target cost. In addition to the price adjustment based on contractor costs, incentive provisions may also be based on equipment performance and delivery.

At the outset the Government and contractor negotiate a target cost, a target profit, a price ceiling and a formula for establishing final profit and price. After performance of the contract, the final cost is computed and audited. The final contract price is then established in accordance with the formula. Where the final cost is less than target cost, the formula provides a final profit greater than the target profit should be. Conversely, where final cost is more than target cost, application of the formula results in a final profit less than the target profit, or even a net loss.

Cost Reimbursement Contracts.

Cost reimbursement contracts differ from fixed price contracts in that a contractor is reimbursed for the allowable costs that he incurs up to an amount originally estimated for contract performance. Risk to the contractor is minimised since he is generally under no obligation to continue with contract performance after the total estimated cost of the contract has been expended.

Cost reimbursement type contracts are not to be used except when: a) it is likely that it will be less costly to the Government, or b) when it is impractical, due to the nature of the supplies or services being procured, to utilise other contract types.

Cost Contract. Under a cost contract, the contractor is reimbursed for his allowable cost of performance but receiv... no fee. Facilities contracts are typical applications of this type.

Cost-Plus-Fixed-Fee.

The cost-plus-fixed-fee type contract is the least desirable type contract for the Government since it affords little or no incentive to the contractor for cost reduction. The contractor is reimbursed his allowable costs and is given a fixed fee established at the contract start. Once the fee is established it is not affected by actual costs and may be adjusted only as a result of formal changes in the work or services supplied under the contract.

Cost-plus-fixed-fee contractc are subject to a statutory fee limitation of 15 percent of the estimated cost at the time of entering into the contract for research, development or experimentation, 10 percent for other type efforts except for architectural and engineering contracts which are limited to a 6 percent fee.

Cost-Plus-Incentive-Fee. The cost-plus-incentive-fee contract provides for the initial negotiation of a target cost, target fee and a minimum and maximum fee together with a fee adjustment formula. The formula for adjustment of fee is based upon the total allowable costs incurred in relation to the target cost. It may also include equipment performance and delivery goals which operate to increase or reduce the fee in accordance with the contractor's achievement of these goals. The formula provides, within limits, for an increase in fee if the total, final, allowable cost is under the target cost and for a decrease in fee when the total exceeds the target. Likewise, the formula may provide for increases or decreases in the target fee depending on the contractor's actual results in the equipment performance or delivery.

CONTRACT MODIFICATIONS

Changes.

The authority for a contract change stems from the contract itself. The "Changes" clause is included in the various types of contracts. It provides that the contracting officer may at any time, by a written order, make changes, within the general scope of the contract, in any one of the following: a) drawings, designs, or specifications, b) method of shipment or packing, c) place of delivery, and d) the amount of Government-furnished property. If any such changes cause an increase or decrease in the

estimated cost of, or the time required for the performance of any part of the work under the contract, the Contractor claim for adjustment must be asserted within thirty days from the date of receipt by the Contractor of the notification of change.

The principal provisions of the clause may be outlined as follows:

a) The contracting officer can direct the contractor to make changes, within the general scope of the contract, to designated areas of the existing contract agreement.

b) An equitable adjustment to cost, fee and delivery schedule will be negotiated to the extent that each of these elements are affected by the change.

c) The contractor must make a timely claim for any adjustment.

d) The contractor must continue with the contract work as changed pending resolution of any dispute which might arise.

Since the Government is the contracting party with the right of initiating the change to the contract and since the contractor is obligated to proceed with the work as changed, contract modification by the "Changes" clause is described as a unilateral action. It rests with the Government by contract provision.

Supplemental Agreements.

In the preceding section it was pointed out that a contract change was unilateral because the right to accomplish the change was vested in only one of the parties to the contract. A supplemental agreement is bilateral. It requires the formal assent of both parties to the contract.

The distinction between a contract change and a supplemental agreement can be drawn by looking at the contract change provision. If a change initiated by the Government has no effect on cost, fee or schedule under the contract, the change is fully accomplished by the unilateral action of the Government in issuing the change. If an adjustment to cost, fee or delivery schedule is required by the change, this new agreement of the parties is expressed by the bilateral action of a supplemental agreement.

In the discussion of the operation of value engineering contract provisions on the following pages it will be noted that the "Changes" clause may and supplemental agreements will be utilized to implement value engineering change proposal (VECP's).

ASPR PROVISIONS FOR VALUE ENGINEERING

The Armed Services Procurement Regulation first incorporated value engineering clause provisions in 1959. ASPR Revision 8, 15 March 1962, established provisions for value engineering which could either require or encourage contractors to perform value engineering studies. ASPR Revision 13 (1960 Edition), 31 December 1962, added a new Part 17 to Section I of the ASPR entitled "Value Engineering." It established requirements for the inclusion of value engineering clauses in defense contracts. This new section was revised in November 1963 by ASPR Revision 3 and is the current ASPR on value engineering.

This Guide will present the major portions of this Section. It begins with a brief statement of the purpose of value engineering.

> 1-1701 Policy.
>
> (a) General. Value engineering is concerned with elimination or modification of anything that contributes to the cost of an item but is not necessary to required performance, quality, maintainability, reliability, standardization or interchangeability.

It then continues with a functional type definition and DoD policy.

> Value engineering usually involves an organized effort directed at analyzing the function of an item with the purpose of achieving the required function at the lowest overall cost. As used in this Part, "value engineering" means a cost reduction effort not required by any other provision of the contract. It is the policy of the Department of Defense to incorporate provisions which encourage or require value engineering in all contracts of sufficient size and duration to offer reasonable likelihood for cost reduction. Normally, however, this likelihood will not be present in contracts for construction, research, or exploratory development.

Revision 3 to ASPR (15, November 1963) deleted the previous value engineering program requirement without incentives, leaving the present two types of value engineering contract clauses.

> Value engineering contract provisions are of two kinds:
>
> (1) value engineering incentives which provide for the contractor to share in cost reductions that ensue from change proposals he submits; and
>
> (2) value engineering program requirements which obligate the contractor to maintain value engineering efforts in

accordance with an agreed program, and provide for limited contractor sharing in cost reductions ensuing from change proposals he submits.

The reason why these contract clauses were developed are stated next:

1-1702 Value Engineering Incentives.

1-1702.1 Description. Many types of contracts, when properly used, provide the contractor with an incentive to control, and reduce costs while performing in accordance with specifications and other contract requirements. However, the practice of reducing the contract price (or fee, in the case of cost-reimbursement type contract), under the "Changes" clause tends to discourage contractors from submitting cost reduction proposals requiring a change to the specifications or other contract requirements even though such proposals could be beneficial to the Government. Therefore, the objective of a value engineering incentive provision is to encourage the contractor to develop and submit to the Government cost reduction proposals which involve changes in the contract specifications, purchase description or statement of work. Such changes may include the elimination or modification of any requirements found to be in excess of actual needs regarding, for example, design, components, materials, material processes, tolerances, packaging requirements, or testing procedures and requirements. If the Government accepts a cost reduction proposal through issuance of a change order the value engineering incentive provision provides for the Government and the contractor to share the resulting cost reduction in the proportion stipulated in the value engineering incentive provision.

The next section outlines those contracts which are required to contain a value engineering incentive contract provision.

1-1702.2 Application.

(a) Except as limited by paragraph 1-1702.3 below, a value engineering incentive provision shall be included in all advertised and negotiated procurements in excess of $100,000 unless (1) a value engineering program requirement is included in the contract in accordance with 1-1703.2, or (2) the Head of the Procuring Activity has determined that value engineering offers no potential for cost reduction, as, for example, where a particular contract or class of contracts is of insufficient duration to allow value engineering proposals to be processed, or where the item or class of items being procured is a commercial product whose design and cost is controlled by the commercial market.

> Value engineering incentive provisions also may be included in contracts of less than $100,000 at the discretion of the contracting officer.

Note that the word "shall" is used to describe the application of value engineering incentive provisions. The only exceptions to this requirement are: a) contracts under $100,000, b) contracts which contain the value engineering program requirement clause, c) contracts which the Head of the Procuring Activity determines do not offer a potential for cost reduction, or d) contracts excepted by Section 1-1702.3.

Paragraph (c) sets forth certain guideline parameters for establishing share lines when the value engineering incentive contract clause is utilized.

> (c) The precise extent to which the contractor should share in cost reduction must be tailored to the particular procurement. In the case of firm fixed-price contracts, fixed-price contracts providing for escalation, and fixed-price contracts providing for prospective redetermination, the contractor's share in any cost reduction normally should be 50%, and in no event greater than 75%. However, if such contracts are not awarded on the basis of adequate price competition, a contractor's share of less than 50% may be appropriate. In the case of an incentive type contract, if it is determined that reasonable certainty exists that cost savings can be accurately estimated, the contractor's share may be up to 50%; if such a certainty does not exist, his share should be in accordance with the maximum over-all cost incentive pattern of the contract.

Note that firm fixed price contracts will ordinarily have a contractor share line of between 50 percent and 75 percent. Incentive type contracts which have the value engineering incentive clause may have a contractor share line of up to 50 percent.

Paragraph (e) covers the allowability of value engineering costs.

> (e) Since the value engineering incentive clause does not require the contractor to perform value engineering, it is intended that the inclusion of the value engineering incentive clause in itself will not increase costs to the Government beyond those considered reasonable for the conduct of the contractor's business or the performance of the contract. Where cost analysis is required, cost allowability will be determined in accordance with normal application of the principles and the procedures provided in Section XV. Accordingly, where a contractor already has a value engineering program, the Government will bear a reasonable and allocable share of the cost of this program, but inordinate

value engineering cost increases incurred solely because of inclusion of the clause shall not be allowed. Similarly, where a contractor does not have a value engineering program in existence, proper allocable costs of instituting a reasonable value engineering program are allowable.

The second type of contract clause, the "Value Engineering Program Requirement" clause is explained next.

1-1703 Value Engineering Program Requirements.

1-1703.1 Description. A value engineering program requirement is a contract provision that obligates the contractor to engage in a program requiring a specified level of value engineering effort. It differs from a value engineering incentive in that the scope and level of effort required by the Government are specifically stated as an item of work in the contract schedule. It also differs in that benefits are expected to result not only from the development of specific cost reduction change proposals, but from a continuous value engineering effort by the contractor in all or selected phases of contract performance and from the submission to the Government of reports reflecting the results of such effort. The principal goal of a value engineering program requirement is to realize the potentialities of value engineering, insofar as practicable, at a time when it will do the most good, i.e., in the initial stages of the design-development-production cycle, so that specifications, production drawings and methods will reflect the full benefit of value engineering as early as possible. The particular value engineering program to be required should be tailored to the particular contract situation with a view toward this goal, and shall be set forth in the contract schedule as a line item. The "Value Engineering Program Requirement" clause provides for contractor sharing in savings ensuing from the adoption of resulting change proposals.

Note that any time a contract contains a value engineering program requirement, it should specifically denote the level of effort. The program requirement is a statement of work item of the contract and should be treated as such.

Section 1-1703.2 prescribes the type of contract situation where the "Value Engineering Program Requirement" clause is to be utilized.

1-1703.2 Application.

(a) Except as limited by 1-1703.3 below, a value engineering program requirement shall be included in each cost-plus-fixed-fee contract in excess of $1,000,000, unless the Head of the Procuring Activity has determined that the potential for cost reduction does not justify the effort involved

> in the establishment of a special value engineering program. In addition, a value engineering program requirement may be included in cost-plus-incentive-fee contracts in excess of $1,000,000 if the contracting officer determines that the lack of a firm specification, precise purchase description or detailed statement of work would be likely to render a value engineering incentive provision incapable of realizing the contract's potential for value engineering cost reduction. Under these same conditions, a value engineering program requirement may also be substituted for a value engineering incentive provision in a fixed-price type contract if approved by the Head of the Procuring Activity or his designee. If a value engineering program requirement is otherwise applicable, it may be included in contracts of less than $1,000,000.

Paragraph (c) sets forth certain guideline parameters for establishing value engineering incentive share lines when the value engineering program requirement clauses are utilized.

> (c) When a value engineering program requirement is included, the precise extent to which the contractor should share in cost reductions ensuing from the adoption of any acceptable change proposal must be tailored to the particular procurement situation. The percentage of contractor sharing shall be stated in the solicitation although this percentage may be a subject of negotiation prior to award. In the case of firm fixed-price contracts, fixed-price contracts providing for escalation, and fixed-price contracts providing for prospective redetermination, the contractor's share shall in no event be greater than 25%.. In the case of an incentive type contract, if it is determined that reasonable certainty exists that cost savings can be accurately estimated, the contractor's share may be up to 25%; if such a certainty does not exist, his share should be in accordance with the maximum overall cost incentive pattern of the contract. In the case of cost plus fixed fee contracts, the contractor's share of the savings shall normally be 10% and shall not exceed this figure.

Paragraph (e) covers the allowability of value engineering costs.

> (e) Except to the extent that the price or estimated cost of a contract includes an amount specifically to cover a required value engineering program, the inclusion of a value engineering program requirement should not in itself increase costs to the Government beyond those considered reasonable for the conduct of the contractor's business or the performance of the contract. Accordingly, when a contractor already has his own value engineering program, the Government will also bear a reasonable and allocable share of the cost of such program, to the extent not included in the cost of the value engineering program required by the contract. Inordinate value engineering cost increases in

the contractor's own program, incurred solely because of inclusion in the contract of the value engineering program requirement, shall not be allowed. Similarly, where a contractor does not have the value engineering program in existence, proper allocable costs of instituting a reasonable value engineering program to the extent not included in the program required by the contract are allowable.

Paragraph 1-1705.1 is the incentive clause to be used for the contract types stated.

1-1705.1 Value Engineering Incentive Clause for Firm Fixed-Price Contracts and Fixed-Price Contracts Providing for Escalation. Value Engineering Incentive (Aug. 1963)

(a) This clause applies to cost reduction proposals initiated and developed by the Contractor for changing the drawings, designs, specifications or other requirements of this contract. This clause does not, however, apply to any such proposal unless it is identified by the Contractor at the time of its submission to the Contracting Officer, as a proposal submitted pursuant to this clause. The cost reduction proposals contemplated are those that:

(1) would result in less costly items than those specified herein without impairing any of their essential functions and characteristics such as service life, reliability, economy of operation, ease of maintenance, and necessary standardized features; and

(2) would require, in order to be applied to this contract, a change order to this contract.

Paragraph (a) (2) recognizes the fact that there are many cost reduction ideas which can be effected without requiring a contract modification. The purpose of the "Value Engineering Incentive" clause is to promote cost reduction which could not be achieved unless the contract were changed. Those ideas which do not require a contract change may be implemented by the contractor as he sees fit. He retains 100 percent of any such cost reduction. Value engineering incentive provisions apply only to cost reduction proposals which require a change order to the contract for their adoption.

Paragraph (b) defines the information which the contractor must submit with a value engineering change proposal.

(1) a description of the difference between the existing contract requirement and the proposed change, and the comparative advantages and disadvantages of each:

(2) an itemization of the requirements of the contract which must be changed if the proposal is adopted and a recommendation as to how to make each such change (e.g., suggested revision):

(3) an estimate of the reduction in performance costs that will result from adoption of the proposal taking into account the costs of implementation by the Contractor, and the basis for the estimate:

(4) a prediction of any effects the proposed change has on other costs to the Government, such as Government-furnished property costs, costs of related items, and costs of maintenance and operation:

(5) a statement of the time by which a change order adopting the proposal must be issued so as to obtain the maximum cost reduction during the remainder of the contract, noting any effect on maintaining the contract delivery schedule; and

(6) the dates of any previous submissions of the proposal, the numbers of any Government contracts under which submitted, and the previous actions by the Government, if known.

Paragraph (c) limits the Government liability.

(c) The Government shall not be liable for any delay in acting upon, or for any failure to act upon, any proposal submitted pursuant to this clause. The decision of the Contracting Officer as to the acceptance of any such proposal under this contract shall be final and shall not be subject to the "disputes" clause of this contract. Unless and until a change order applies such a proposal to this contract, the Contractor shall remain obligated to perform in accordance with its existing terms. The Contracting Officer may accept in whole or in part any cost reduction proposal submitted pursuant to this clause by issuing a change order which will identify the cost reduction proposal on which it is based.

Paragraph (d) describes the procedure for computing the contract price reduction.

(d) If a cost reduction proposal submitted pursuant to this clause is accepted under this contract, an equitable adjustment in the contract price and in any other affected provisions of this contract shall be made in accordance with this clause and the "Changes" clause of this contract. If the equitable adjustment involves a reduction in the contract price, it shall be established by determining the amount of the total estimated decrease in the Contractor's cost of performance resulting from the adoption of the cost reduction proposal, taking into account the cost of implementing the change by the Contractor, and reducing the contract by...*.. percent (...*..%) of such decrease. If the equitable

*Government share

adjustment involves an increase in the contract price, such increase shall be established under the "Changes" clause rather than under this paragraph (d). The resulting contract modification will state that it is made pursuant to this clause.

Paragraph (e) permits the contractor to make multiple submissions of a cost reduction proposal.

(e) Cost reduction proposals submitted under the provisions of any other contract also may be submitted under this contract for consideration pursuant to the terms of this clause.

Paragraph (f) gives the contractor the right to restrict the Government's use of any data submitted under this clause until such time as the Government accepts the proposal.

(f) The Contractor may restrict the Government's right to use any sheet of a value engineering proposal or of the supporting data, submitted pursuant to this clause, in accordance with the terms of the following legend if it is marked on such sheet.

For fixed price incentive (FPI) type contracts, the value engineering incentive clause above is modified by substituting the alternate paragraph (d) as set forth in 1-1705.2 It describes the process for adjusting the target conditions.

1-1705.2 Value Engineering Incentive Clause for Fixed-Price Incentive Contracts (Firm Targets). For fixed-price incentive contracts (firm targets), insert the clause set forth in 1-1705.1 above, modified by the substitution of the following paragraph (d) thereof:

(d) If a cost reduction proposal submitted pursuant to this clause and affecting any of the items described in paragraph (a) of the "Incentive Price Revision (Firm Target)" clause of this contract is accepted under this contract, an equitable adjustment in the total target price of such items and in any other affected provision of this contract shall be made in accordance with this clause and the "Changes" clause of this contract. The equitable adjustment in such total target price shall be established by (1) determining the amount of the total estimated decrease in the Contractor's cost of performance resulting from adoption of the cost reduction proposal, taking into account the cost of implementing the change by the Contractor, and (2) deducting the full amount of this estimated decrease from the total target cost and adding .... percent (......%)* of such amount to the

*Insert the appropriate percentage, i.e., the contractor's share (see 1-1702.2(c)).

total target profit relating to such items. The maximum dollar limit on the total final price of such items, which is expressed in said paragraph (a) as a percentage of the total target cost thereof, shall be increased by the total amount of any adjustments in the total target profit that have been established pursuant to this clause. If the equitable adjustment involves an increase, in the contract price, such increase shall be established under the "Changes" clause rather than under this paragraph (d). The resulting contract modification will state that it is made pursuant to this clause.

The procedure described above is typical of the ASPR provisions for value engineering incentive operation in cost plus incentive fee (CPIF) Contracts.

The "Value Engineering Program Requirement" clause is then presented. The previous value engineering incentive provision mechanisms are also contained in the program requirements clause. Comment here will be limited to those aspects which differ.

Paragraph (a) of the "Value Engineering Program Requirements" clause requires the contractor to "engage in a value engineering program and submit progress reports thereon." As previously discussed, the level of effort for this program should be specified in the contract schedule and the reporting requirements should be specified in the schedule as to frequency and content. From the third sentence of paragraph (a) down to paragraph (d) the value engineering requirement clause is almost identical with the value engineering incentive clause.

VALUE ENGINEERING SERVICE CONTRACTS

The previous discussions have all considered value engineering as an inclusive element of a procurement. It is also possible to have a procurement solely for value engineering services. This may be obtained from industry, educational institutions and consultants. Agencies of the DoD have utilized this mechanism to contract for several categories of services or equipment: a) value training support and complete Workship seminars, b) value research studies, c) value program development consultation, and 3) value engineering studies of specified equipment projects.

Separate contracts for these or other possible situations are treated as individual procurements. The contract type, structure and procurement

method would be appropriately selected as prescribed by the ASPR and the implementing regulations of the procuring activity.

The use of a separate procurement for the first three cases cited above needs little amplification. They represent identifiable services which can be contract items in themselves. Value engineering studies may be separate procurements for several reasons: a) the project for study may be a DoD in-house developed item which may or may not be planned for fabrication by industry, b) re-procurement of an existing item may be anticipated, pre-procurement study is felt to be justified and is more amenable to outside than to DoD value study, c) a fresh look at an item in addition to or, by other than, the original developer or producer may achieve more varied results, or d) it is considered desirable to contractually separate the value engineering portion of a total contract in order to effect easier control, different type of contract instrument or assessment of results.

In any event, the statement of work or other task description in the contract schedule should clearly specify the task. Contracts for value studies usually identify the item to be studied and may call for submission of mock-ups, working models or prototypes of the contractor's recommended value improvement.

CONTRACTUAL ASPECTS: SUMMARY

A. The purpose of a contract is generally to reduce to writing the conditions, rights and duties which the parties have agreed will bind them and which place the risk of performance on the promisor.

B. All DoD contracts must be awarded by the Advertised Procurement process unless one of 17 exceptions prevails which allow the use of the Negotiated Procurement process.

C. The Negotiated Procurement process allows the submission of "proposals" rather than "bids" or "offers." Proposals are the basis for discussions between one or more contractors and the Government for final agreement on the contract type, form and tasks.

D. Fixed price procurements are characterized by definitive specifications, high contractor financial risk, payment upon delivery and higher profit than cost reimbursement contracts.

E. Cost reimbursement procurements are characterized by areas of uncertainty in the specifications, low contractor risk, payment for progress towards delivery and lower profit than fixed price contracts.

F. The ASPR states that it is DoD policy to incorporate value engineering provisions in all contracts which offer a reasonable likelihood for cost reduction.

G. Two types of value engineering contract provisions are: a) "Value Engineering Incentive" clause which provides for sharing of cost reductions which result from contractor generated and Government approved proposals which change contractual requirements, and b) "Value Engineering Program Requirements" clause which obligates the contractor to perform certain tasks and which also allows sharing as above, but provides a smaller percentage for the contractor.

H. Value engineering incentive provisions provide a mechanism and incentive for contractor's efforts to propose savings which can be achieved only by changing a contractual requirement.

I. The cost of a contract with a value engineering program requirement clause may include "... an amount specifically to cover a required value engineering program ..."

Chapter 8: Program Management

This Chapter discusses some of the management aspects of value programs... the factors presented are annotated for their applicability to value programs in industry and in the DoD... Value engineering personnel selection criteria... and duties are presented... Some guidelines are offered for the organizational aspects of value engineering... Program control elements of planning... motivation... and information services are described... Details of the results of value engineering efforts... and an approach to assessment are given.

CHAPTER 8

PROGRAM MANAGEMENT

PERSONNEL

This section will discuss the selection, training and duties of value engineering personnel, i.e., those who have one or more value engineering program elements as their assigned primary responsibility. They are members of a designated value engineering group and have 'value engineering' as their job description. The factors noted below are guidelines based upon current practices and past experiences.

Selection.

Previous Experience. A candidate should have previous experience in one or more of the major specialty areas that he is most likely to deal with. Previous assignments in procurement, logistics, finance, fabrication or price analysis are helpful. His knowledge of the personnel, operation, problems and jargon facilitates communication. This is especially useful if these were gained with the installation that is considering him for a value engineering assignment

Personality. Character traits are the most significant selection criteria. This results from the nature of the value engineering task. The performance of value studies and the development of procedures for value assurance activities by other personnel requires extensive personal contact with numerous people from several of the organizational elements. The ability to successfully accomplish these contacts and to react in a positive, constructive manner cannot be overemphasized.

Personality traits which are positive selection factors include:

a) Capacity to deal with people without arousing antagonism.

b) Sensitivity to the personal viewpoint that others have of the value problem and its implications to them.

c) Initiative to undertake tasks of known difficulty in previously unexplored areas.

d) Willingness to be identified with a group that is involved with perturbing the status quo.

e) Articulate in oral and written expression.

f) Not easily discouraged and possess the capability to rebound when discouraged.

g) Maturity of thought and action (which may have no positive correlation with chronological age).

Formal Education. A university degree is a desirable, but not mandatory, prerequisite. If the assignment is expected to be mostly value studies, design reviews, or specification reviews of advanced technology items, an appropriate technical degree is certainly useful. When, however, the major effort will be to help cost-determining people to do their own value engineering, a formal technical education diminishes in importance to other criteria. A degree does provide evidence that one otherwise personally unknown to the selector has been exposed to and has demonstrated the knowledge and diligence needed to complete a college curriculum. No college offers an undergraduate degree in value engineering at this time.

Value Training. Universities, consultants and industry offer value training courses ranging from one day to 80 hours. Completion of one or more of these exercises is a positive factor, especially if it was a credit course or used formal examinations. The minimum requirement is successful completion of a Workshop Seminar of at least 40 hours and preferably 80 hours. This not only provides specialty education, but also simulates the actual work. He is then better able to decide upon it as a full time assignment.

Personnel may start their value engineering education on the job. This approach must be supplemented by outside reading and supervision. A workshop course should be taken at the first opportunity. On the job training of less than a year would benefit from formal classroom value training.

Sources. From the above criteria it can be seen that prior observation of candidates is best to make a good selection. A likely first source is the personnel at the installation. A selection from there will have knowledge of part or all of the operation and its major products. The substance of value engineering theory is more easily learned than the intricacies of the agency.

Value engineering Workshop Seminars are excellent sources of potential assignees. They offer an opportunity to see demonstrations of the attributes discussed above. Natural inclinations for value work will be manifested -- the selector need only observe critically.

Duties and Responsibilities.

The duties of value engineering personnel can be broadly divided into three categories: a) performance of value studies, b) implementation of program task elements, and c) consultation or specialty assistance. Value engineering personnel are not solely responsible for the value of the organization's items. This burden lies upon all who make decisions which contribute to final cost.

Performance of Value Studies. This responsibility includes all elements of application of the theory to specific projects. It may be solo performance or as a member of a task force. This project may have been generated as the output of other efforts, such as cost targets, or their selection may be included in this activity. In either event, this category includes all efforts up to and including the recommendation of corrective action. It currently is the most common duty of value engineering personnel. It should not be delegated to any other organizational unit.

Implementation of Value Program Tasks. This category involves the value program elements which are delegated to other organizational units. Value engineering personnel responsibilities here include the efforts to: a) prepare the value engineering portion of the procedures, b) develop the technical capabilities necessary to implement the procedures, c) assist in their performance as requested, and d) monitor for adequate satisfaction of the value aspects.

Each organization needs to locate points of primary responsibility for these tasks. To a large extent these may initially be in the value engineering

group itself. In these cases surveillance should be maintained to assure that efforts are not carried to the point of duplication or beyond the time for turnover to more logical areas of primary responsibility. Most of the tasks in this category will require value engineering assistance after turnover. Value training is an example of this group.

Consultation and Specialty Assistance. This area covers those efforts not associated with identified tasks. Briefly, it represents technical advice on the value engineering aspect of any current application by personnel at the installation. This situation occurs sporadically and cannot be scheduled. The individual involved: a) needs to recognize that he has a value problem, b) realize that he needs specialty assistance, and c) alert the value engineering organization for aid. Typical examples of this category include:

a) Consultation with equipment designers.

b) Evaluation of the value aspects of proposed changes.

c) Assessment of the value engineering portions of RFP's, proposals and subcontracts.

d) Surveys of supplier value programs.

e) Determination of the technical value engineering consequences of contract clause selection.

Career Development.

All of the aspects of career development for any career field apply to value engineering. Some salient features peculiar to this field may be briefly mentioned. These largely have to do with the nature of this work that causes it to be involved with so many other specialties and its relative youthfulness as a recognized career field.

Management recognizes that value engineering has been extended to only a fraction of its potential. Career development of the participating personnel will be required before this latent capacity can be fully realized. The subject can be examined from two viewpoints: a) development of the individual, and b) self-improvement.

Advanced Value Training. At the time of preparation of this Guide there was no formal program of value training which was beyond the material in the DoD Value Engineering Training Guides. Some value engineering R & D

needs to be done before an advanced value curriculum will be feasible. Meanwhile, training in the areas with which value personnel have operating interfaces is useful. Education in the human factors aspects of value work is a logical part of career development. There should be advanced technical training in the theory or practice of the items handled. Finally, there may be portions of the daily work which need improvement, for example, technical writing.

Value engineering management needs to plan career development exercises for its people. These plans need to be reduced to practice and assessed for their effectiveness. It is likely, as past experience has demonstrated, that few personnel have all the knowledge they need to achieve maximum results from this theoretically simple, but otherwise complex, discipline.

Self-improvement. It is only a short while after starting a value engineering assignment before one realizes the lack of much needed knowledge. Action to reduce this lack is so incumbent upon value engineering personnel that this subject could have been discussed in the earlier section on Duties and Responsibilities. It was placed here in recognition of management's role to identify the most needed areas and to support corrective actions. Many avenues are available for self-improvement. These need not be detailed in this Guide.

ORGANIZATION

A designated value engineering organization is a fundamental element of a value program in the DoD and industry. The size, structure, level, and location of a value engineering group cannot be presently specified; they are dependent upon the installation served. Some guidelines will be provided concerning size and location. The structure will be discussed in terms of the coordination and operation duties of a value engineering group. An organizational approach will be suggested to most economically satisfy these duties. The management level that the value engineering group should report to can only be discussed in principle.

Each installation needs to evaluate its needs in terms of the following guidelines and the other data in this Guide to make its organizational decisions. The initial decisions made when the value program is installed should be re-assessed at periodic intervals of no greater than every six months for at least the first two years.

Size.

The manloading depends upon the size of the facility served and the anticipated workload. The lower limit is one man full-time and may reach 10 to 15 people at installations that have sufficient personnel and products. The value engineering organization may require an inordinately large staff when the installation's value program is first installed. As the program gathers momentum, primary responsibility for some of the task elements is transferred to other groups. The value engineering staff should either decrease or shift their focus to operating tasks.

Structure.

An insight into the structure of a value engineering organization can be gained by considering two broad categories of its duties: a) coordination and b) operations. The using agency must evaluate its needs and make specific assignments of these categories to a selected number of personnel. Initially the responsibility for coordination and operations may be vested in one focal point. As the value program is reduced to practice it may be desirable to separate these functions. If this is done, the coordination function is a logical staff assignment and operations should be a line function.

Coordination Function. The coordination function includes program development, implementation, control, assessment and the support of those value engineering task elements assigned outside of the value engineering group. Some specific responsibilities common to industry and the DoD are:

a) Develop and participate in the internal value training or indoctrination program. If the facility has an internal training capability, the value engineering coordinator assists in the technical aspects of the value engineering training courses.

b) Develop and disseminate technical data (such as value standards, cost per function, and cost of standard machine operations) which will aid the operations personnel.

c) Review procurement requirements to determine which value engineering clause is technically most applicable to the specified requirements, contract type and acquisition phase.

d) Assess the effectiveness of the internal and contractor value engineering programs.

e) Maintain an interchange of technical and cost information with other functional groups such as reliability, maintainability, logistics, quality and production.

f) Review suggested projects for final selection and make study assignments to operations personnel or to task forces.

g) Coordinate the administration of contractor value engineering efforts if there are several simultaneous procurements with each having its own operational value personnel.

Operations Function. The operations function of a value engineering organization has primary responsibility for certain value engineering program task elements and for maintaining a dynamic interface with other operational groups that affect end item value. Some of the specific duties in the DoD and industrial value operations are:

a) Perform those value engineering program task elements delegated by the installations value program plan, directives, regulations, specifications, and other regulatory documents. These will normally be the performance of value engineering studies, specification and design value reviews, and the generation of value engineering proposals which recommend a lower end item price.

b) Develop specific cost visibility data for the type of item or processes commonly handled.

c) Provide technical specialty support for other areas of the installation as required (usually performed by the coordinating function).

d) Administer contractor value engineering programs for specific procurements. This includes program plan review, report review, participation in training, and coordination of value engineering change proposal submission and processing.

Organizational Approach. The coordination and operational elements may be vested in one designated group. This group can be subdivided, formally or informally, to satisfy both sets of duties. When the operational tasks (especially the value studies) have a variable workload to support several projects under the installation's control, a centralized value engineering organizational structure may be optimum. Under this "pool" concept, the value engineering personnel are technically assigned to projects as required while administratively reporting to the central value engineering group.

The pool concept may provide optimum manpower utilization. The value personnel will gain increased familiarity with the installation's items of responsibility, procedures and overall value problems. Manpower peaks and valleys may be alleviated by the administrative ease of assignment changes from between projects according to their variable needs and in between for coordination function duties.

Level.

There is no minimum management level which a value engineering organization must hold in order to successfully perform its mission. If the two basic value functions are separated, the coordination function will usually report to a higher management level than the operations function. The operations personnel could report directly to the coordination function which might be the designated value management focal point for the installation. If the operations function is distinct, it should be visible on the organization chart.

Location.

There are no constraints upon the location of the coordination function within the parent organization. Value engineering is within the current structure of the DoD Cost Reduction Program. Hence, a logical organizational location is for value engineering to be allied with the installation's cost reduction focal point.

If the operational function is separated, it normally would be associated with one of the technical elements. Specifically which one will depend upon the items usually handled. In no event should the organizational location tend to subordinate the value engineering efforts to previous primary responsibility. Care must also be exercised that placement will not restrict its application. For example, value engineering has not been completely effectively applied to the R & D programs of an installation when it has been organisationally assigned to the production division.

PLANNING

The achievement of maximum benefit from a value engineering program requires planning for installation, operation, and control. In industry this may be manifested by a value engineering program plan based upon the statement of work in the contract. In the DoD a plan is equally necessary. It may be derived from exhibits, specifications, directives and regulations. The program plan acts as a communication link between the contractor and the DoD and between the agency and higher authority. It conveys the depth of understanding by its specific task descriptions, manloading and schedule. It becomes the basis for pricing and subsequent measurement of the value program effectiveness.

A program plan should describe all aspects of the planned efforts and should contain the following information:

a) Appropriate reference should be made to regulatory or contractual documents which required its preparation.

b) The intent and specific objectives of the particular value engineering program must be delineated. It should have sufficient detail to permit other authorities to understand how these objectives are planned to be met and the expected results.

c) An organization chart should be included to convey a clear understanding of the value engineering group nomenclature, level and location with respect to the other organizational elements which it will deal with. These latter include engineering, fiscal or finance, procurement, logistics, and fabrication.

d) A detailed description of the task elements to be performed must be included. This portion of the program plan should reflect applicable required directives and the value engineering needs of the project or installation.

e) A program schedule is needed in milestone or other equivalent format which portrays the relationships between the tasks to be performed and the calendar or the overall project schedule.

The tasks presented in the program plan should represent suitable selections appropriate to the installation or to the procurement. They should be commensurate with the level of funding, manpower availability and the acquisition phase of the items that will be treated. If the level of effort does not permit implementation of all possible value tasks, the program plan should present the rationale for its selections.

The value engineering program plan should be critically re-examined at regular intervals (roughly every six months) in the light of achieved progress, expenditures and results. Revisions should be made when necessary to maintain the document as a program control parameter.

Motivation.

The DoD is promoting the concept of incentive contracting to stimulate contractors to greater economy and performance through increased profit. A "Value Engineering Incentive" clause is one aspect of this motivation. As discussed earlier, this has caused contractors to look to their individual employees as significant factors in profit achievement.

Within the DoD, regulations and directives have stressed the personal aspects of cost effective performance. These and other factors are effective to the extent that they are stressed and practiced.

It is a value engineering management responsibility to positively participate in the motivation of individual cost effective performance. Each such manager needs to develop a series of mechanisms to generate a "value climate" at his installation.

Information Services.

The subject of cost and cost reduction is currently receiving much attention. The incentive mode of contracting is stimulating, and even providing the contractor with assistance to reduce costs. New cost control techniques such as PERT/Cost, the weighted guidelines method of profit computation, computer applications to cost effectiveness studies, films, handbooks, manuals, directives, letters, and regulations have all been promulgated which speak in terms of reducing costs. Industry has responded with professional societies, studies, analyses and recommendations for better means of controlling and reducing cost.

These actions, coupled with the establishment of cost reduction quotas, have engendered an atmosphere prone to public announcements of positive responses. Industry and DoD representatives have prepared newsletters, press releases, exhibitions of success stories and articles. None of this is harmful in itself; but, it must be pointed out that since value engineering is a cost reduction oriented discipline, it is heavily involved. Value engineering program management needs to recognize the applied pressures and react in a manner which will not cause subsequent disavowal of prematurely claimed results.

Positive control procedures must be instituted by value engineering program management for information release. These must, of course, be consistent with agency directives. A balance of information release needs to be maintained so that successful applications may be used in the motivation program previously mentioned. In all cases, extreme care should be exercised so that value engineering generated information reports or releases do not imply that the original designer (or his organization) was incompetent and do not imply more credit to a value engineering organization than it is due for its part in the cost reduction efforts of many.

RESULTS

The objective of value engineering is the improvement of value by the reduction of cost. The results of value engineering efforts can be considered in three categories: a) mandatory, b) desirable and c) potential. Desirable and potential results may be either direct or indirect. Direct results are the achieved cost reductions which can be unambiguously measured. They frequently occur in other than cost units: a) improvements in reliability, b) improvements in ease of supply, and c) increases in the opportunity for competitive procurement. These other factors, although real, may be subordinated to claims of savings under severe cost reduction pressures.

A significant portion of value engineering achievements is gained through the efforts of personnel other than the designated value engineering personnel. Their value results are not always clearly visible nor immediately evident. Thus, they may be called indirect; this does not mean that they are not real. The application of value engineering to the early design phase has also produced results which are more easily and realistically measured in units other than dollars. There is, for example, an improvement in a company or DoD agency cost-consciousness atmosphere. This is a highly desirable result, since the lack of this climate is an environmental factor that has contributed to the need for this subject. Indirect benefits also result from increasing the capability of personnel to produce a more cost-effective item than they might have otherwise.

Contractor Efforts.

Contractor, and some DoD, value engineering results can be most conveniently examined in light of the methods that the DoD uses to obtain them. The results of value engineering service contracts are derived directly from the statement of work and need no amplification here. However, the results of value engineering efforts obtained as an element of a larger procurement may be discussed. The DoD uses one of two types of clauses to seek these results.

"Value Engineering Incentive" Clause Results. The ASPR states that, "The objective of a value engineering incentive provision is to encourage the contractor to develop and submit to the Government, cost reduction proposals which involve changes in the contract specifications, purchase description or statement of work." It encourages the implementation of a value

engineering program. It does not have any mandatory results. Nothing is required; nothing must be reported. Furthermore, the desired results can be obtained only if the clause is invoked. Desired and potential results of the direct and indirect types may be realized from application of the incentive clause.

Direct Results. The direct (and desired) results are proposals to change contractual requirements which will lower the contract price. The ASPR speaks of these as "cost reduction proposals" submitted pursuant to the clause. These are sometimes called VECP's when the contractor uses the Engineering Change Proposal (ECP) form based upon ANA Bulletin 445A for this purpose. Other nomenclature is used for proposals which either do not (or may not) use the ECP format. In any event, the submission of these proposals represents the contractor's results. Processing and dispositon of these proposals are the DoD agency results. (Assessment includes the evaluation of the contractor's results in the light of their disposition.)

These desired direct results can be quantitatively expressed in dollar units. They may be obtained from the contractor submittals and verified by the supplemental agreements which actually change the contract price. The Government share of the cost reduction is the DoD direct result. The Government's usage of these changes on other procurements is an additional potential result. This result is greater than the direct result because the Government does not have to share the cost reduction.

Indirect Results. The indirect results that are possible outputs of contractor value engineering efforts under incentive clause coverage are difficult to specify. They represent the capability improvements emanating from value training, value climate improvement and personal motivation factors.

The contractor may also produce change proposals which he may reduce to practice without the approval of contracting officer. These internal changes may represent immediate or potential results to the DoD. If these changes are made on an FPI or CPIF contract they will mean a lower final contract cost than if they had not been implemented. The Government result is its share of the resultant underrun, when it occurs. It needs to be identified and verified if a positive result claim is to be made. (These results may be expressed as cost avoidances.)

If the contract is not an incentive type, these indirect results are seen as potential results by the DoD. They may be manifested as lower cost of future procurements from that contractor.

"Value Engineering Program Requirements" Clause Results. The ASPR clause state, that, "The contractor shall engage in a value engineering program, and submit progress reports thereon, as specified in the Schedule." Program requirements clause coverage will produce mandatory, desired and potential results.

Mandatory Results. The minimum mandatory results are the "engagement" in a value engineering program and the submission of reports. The Statement of Work, or other portion of the contract Schedule, may define additional mandatory results. For example, the submittal of a value engineering program plan has previously been suggested as a requirement. Additionally, program descriptions, specifications or exhibits may be incorporated which will require specific task performance. In any event, it should be noted that the mandatory result is task performance evidenced by document submittals, not cost reduction. These mandatory results are indirect. They can be expressed in terms of actions taken. It is extremely difficult to realistically convert these actions into equivalent dollar consequences.

There is one other category of mandatory result in these cases. The ASPR clause states that "... the contractor shall submit any cost reduction change proposals resulting from the required program." It is the submission of these rather than their generation that is mandatory. When submitted they can be viewed as direct results and treated in this respect similar to the previous discussion of the "Value Engineering Incentive" clause.

Desirable and Potential Results. These are indirect and are substantially the same as previously discussed under the incentive provision. However, they have a higher probability of being obtained in this case. This is because direct efforts are being performed to gain them. Additionally, the potential results are increased because the Government obtains the right to use submitted data, including cost reduction proposals, even if they are not applied to the contract at hand.

DoD Efforts.

Value engineering application within DoD agencies also produces direct and indirect results. It is not pertinent to categorize these here as mandatory or nonmandatory. This is a command consideration of the mission assigned to the value engineering group. The significant point is that the results of DoD value efforts manifest themselves as larger benefits to the Government. No sharing of results occurs. All of the factors of identifying direct and indirect results previously discussed apply in-house. As also noted before, the DoD actions associated with the administration of contractor programs are identifiable results.

ASSESSMENT

Assessment is used here to mean the appraisal of extant or completed value engineering efforts for effectiveness and control. It includes: a) audit, b) evaluation, and c) determination of corrective actions. Each of these three factors, but especially the audit, should reflect the consideration of results discussed previously.

Assessments may be made of contractor or DoD value programs. The installation's value engineering personnel should contribute to the audit procedure development and analysis of its results but probably should not actually conduct audits at its own location. Formal assessments should be performed annually.

Audit.

The audit is a fact finding exercise. An agenda appropriate to the installation or project to be audited should be prepared. It should seek facts supported by tangible evidence. The data sought should be of three types: a) what has been done, b) what has not been done, and c) what are the problem areas?

The audit must cover the value engineering operation as well as other organizational elements. The other groups are selected according to their responsibility for value engineering task element performance and for their disposition actions on value engineering change proposals.

Specific audit elements derive from consideration of the programs to be evaluated. Some general facets that should be included are:

a) Does the organization chart show a value engineering activity and illustrate its relation to key functions such as procurement, engineering, fabrication, fincance and project offices?

b) Do procedures and policies exist which delineate the value engineering program tasks, responsibilities and internal operation for the installation?

c) What is the record of applying value engineering projects as exemplified by memoranda, reports, or minutes of meetings?

d) What is the extent to which the program has received support as illustrated by management or command personal and written actions?

e) Do procedures exist and are they followed to assure the use of value engineering results on other programs or items?

f) Have informal assessments been made internally?

Evaluation.

Evaluation may be accomplished by a point rating approach. The agenda used for the audit could have an associated score for the answers to each question. Mandatory results should be weighted most heavily, then desired results and potential results should make the least individual contributions to total score. The resultant point score will be arbitrary but it will isolate corrective action needs. Subsequent audits may be compared for progress consideration.

Corrective Action.

This portion of the assessment derives from the evaluation with qualifications due to exposed problem areas. The entire assessment process is meaningful only if the corrective action needs are communicated to those responsible.

SUMMARY: PROGRAM MANAGEMENT

A. Personality traits which indicate a positive capability to react to the needs and problems of other personnel without arousing antagonism are the most significant selection criteria for value engineering personnel.

B. An installation should have a designated value engineering group. The exact organizational location and level of this group is dependent upon the size and type of facility, its products, policies, and its planned program.

C. Optimum operation of a value engineering program is assisted by initial planning of tasks, schedules, budgets and manloading. These must be periodically evaluated for comparison with actual occurrences.

D. The results of value engineering activities include: a) mandatory contractor results of value program operation from "Value Engineering Program Requirements" clause provision, and b) desired contractor results which include the submission of cost reduction proposals and achievement of internal cost avoidance by actions which do not require contractual implementation authority. Both of these may become potential results to the DoD for future procurements. Results of DoD actions include direct cost reductions accruing from approved contractor submittals, direct cost reductions accruing from in-house value studies and indirect present and potential results accruing from improving the cost determining personnel capabilities and climate for cost reduction.

E. Assessments of DoD and contractor value engineering programs should be performed annually to audit, evaluate and recommend corrective action of the value engineering organization and all other elements which influence end item cost.

Chapter 9: Value Research and Development

A critical analysis of the value engineering discipline and some applications is presented... the need for improving certain areas is highlighted... some likely topics are offered as value engineering research studies... These include the management aspects of motivation... measurement... unification of several cost oriented disciplines... and improved directives... Other studies are suggested for some technical areas such as source data... Value Standards... Value Figures of Merit... Cost Visibility Standards... and value training improvement.

CHAPTER 9

VALUE RESEARCH AND DEVELOPMENT

The management of any activity must consider its development to meet anticipated needs as well as its current application. Value engineering is not an exception. In fact it has been somewhat delinquent in this respect. This chapter will briefly, and critically, examine its current posture and suggest some possible avenues of exploration. It is a management responsibility to initiate these or other research studies to assure the value of value engineering in the changing pattern of DoD procurement and contract performance.

STATE OF THE ART

Theory.

The evaluation of function is the current manifestation of the value engineering theory. It is not very much different today than when it was originally developed over 15 years ago. It represents a qualitative rather than an exact, quantitative process. This is especially true of the worth values for functions. The current procedure relies upon the personnel's experience and judgment rather than upon scientific method. Its strength as an analytical tool could be greatly improved.

Practice.

The value engineering task elements discussed earlier represent the present level of application practices. Some, especially training, have been practiced in the same manner for the past 15 years. The inclusion of value assurance training in this document and in the Principles and

Applications of Value Engineering Training Guide, is the first basic change in value education.

Some of the value program tasks are recent developments and have not had extensive tests in industry or in the DoD. They contain some decision elements based upon qualitative considerations and subjective application of experience and judgment. The Projects Requirements Evaluation isolation of poor value obligatory elements is an example. Another broad area of potential task improvement is the standardisation of criteria and nomenclature for sub-elements of many value engineering program performance procedures.

POTENTIAL AREAS OF DEVELOPMENT

The research and development of value engineering to improve its yield may be explored in three areas which are logical separations of the types of studies and the places, people or organizations that might perform them. Data needed for performance of some is more readily available in industry, some in the DoD and others could be performed by either. The research activities suggested in this Guide are by no means an exclusive listing.

Management Aspects.

This area covers the aspects of accomplishments through personal contacts, procedures and regulations. For this subject it is the attainment of the objectives of value engineering, especially the long range objective of all cost determining personnel doing their own value engineering. Presently the application of value engineering is highly localised in the hands of value engineering personnel. Studies which culminate in better personal approaches, written procedures and personnel actions might dwell on these subjects:

a) Motivation, reward and correction strategies are needed. Their application would be to all personnel with respect to their use of the value engineering theory in daily job performance.

b) Measurement and assessment nomenclature and standards which quantitatively and realistically express cost reduction results are not adequate at present. These need to be in terms of impersonal benefit to the DoD, rather than to any one discipline such as value engineering. One organisational group might have performed

only a portion of the value effort but may receive inordinate acclaim because it has the same name as the theory or methods that were used.

c) A discipline should be developed that incorporates several presently co-existing elements that have similar high value objectives but use different nomenclature, procedures, and personnel. Some of these have extensive common interfaces, yet operate more or less independently. Typical possibilities are the value engineering, maintainability and reliability fields. A unified theory, similar to systems requirements analysis. that makes common use of the outputs of these three for example, would be a more powerful and efficient instrument than the sum of their separate actions.

d) Procedures and regulations are needed for a more realistic evaluation of value engineering change proposals for their effect upon future procurements and Government installation, operation and logistic costs.

Source Data.

Research studies in this area are needed to generate quantitative data for use in value engineering application. The need for these studies is to supplant the subjective generation of functional cost data with a more realistic basis derived from actual situations. Development of these data could become a basis for more quantitative contractual value engineering arrangements as well as a more realistic assessment of the total impact of proposed value engineering changes.

Value Standards. This nomenclature has been used loosely for some time. Published data, however, is virtually nonexistent. The term is used here to indicate dollar figures that represent reasonably achievable minimum costs for accomplishing specific functions. There is a finite number of possible functions. Standards of cost for achieving the most common ones would be a base for setting the worth or cost targets of items that represent the accomplishment of these functions.

Value Figures of Merit. This title is used to mean terms that express performance features in cost units. They express the variation, as improvement or degradation of performance, in terms of dollars. For example, an equipment reliability could be expressed in terms of the cost of achieving each additional 100 hours between failure as derived from mean time between failure (MTBF) consideration. Complications may be included to express other factors significant to a particular item such as cost in

dollars per unit of signal to noise ratio per 500 hours between failures. The cost consequences of reliability trade offs between alternative hardware designs would then be quantitatively expressed in dollar terms. This would provide increased cost visibility into the design decision process. Performance figures of merit without cost and cost figures of merit are in common use. But this use has generally been in analyses of systems economics, rather than for the unit end item level at which many costs are actually determined.

Cost Visibility Standards. Industrial consideration of the value of alternative approaches is frequently hampered by lack of knowledge of quantitative DoD cost data for the installation, operation and logistics of the items under development or production. This is especially significant in the case of studies which propose changes under value engineering incentive clause coverage. Knowledge of the preceding cost factors and the Government's cost of change processing should be criteria for contractor selection of study items and DoD change evaluation. Several situations have already occurred of DoD rejection of industry proposed value changes due to the cost factors not quantitatively available to the contractor. Parallel problems of inadequate using agency cost consequences could arise in the evaluation and implementation of DoD generated value changes.

Methodology.

Value engineering task performance procedures are susceptible to improvement. This includes those performed by value engineering personnel, and more significantly, those used by all cost determining personnel in their daily work routine. Some of this will be a by-product of the experiences gained as the performance task elements discussed in Chapter 3 are implemented more widely. Formal effort needs to be assigned to accumulate data, analyse and revise these task elements to take advantage of what is learned and to communicate it so that the same lessons need not be re-learned.

One example might be cited here. Value training has been widely practiced for over 10 years. The time required to accomplish the minimum effective presentation of Workshop Seminars is still virtually the same as it was 10 years ago. More efficient procedures would seem reasonably capable of development.

VALUE RESEARCH AND DEVELOPMENT: SUMMARY

A. Value engineering needs development of certain of its methods, procedures and source data to allow a greater realization of its potential.

B. Research studies should be performed to make cost data available which would permit quantitative standards for determining the worth of functions, minimum costs of achieving functions, reasonable costs for performance parameters which include failure consequences and DoD usage cost figures for design and change decisions.

C. The results of current value engineering program task elements should be centrally collected and evaluated for task definition, procedure and application improvement.